Materials
in Design Engineering

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in Design Engineering

MID-NOVEMBER 1960

MATERIALS SELECTOR ISSUE

This Materials Selector Issue of MATERIALS IN DESIGN ENGINEERING features the latest available data on engineering materials, forms, finishes, and joining and fastening methods. The issue consists of two major sections: a Data Section and a Directory Section. Each of these is subdivided to make it as useful as possible. Contents of the entire issue are listed on these two pages; in addition, a more detailed contents page appears at the beginning of most subsections. All subsections are described briefly on the facing page.

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DATA SECTION

The Data Section consists of eight parts. It contains extensive data on the properties of virtually all important engineering materials (including finishes and coatings), the forms in which they are available, and the methods by which they can be joined.

DIRECTORY SECTION

The Directory Section, consisting of two parts, contains the names of the leading suppliers of engineering materials and their forms and shapes. A full explanation of the organization and use of the Directory is given on page 504.

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Comparisons of Materials 11

Based on specific end service requirements

Tables comparing the important engineering materials with respect to a particular property (e.g., tensile strength). The major part of this section is a series of data sheets in which materials are ranked in descending order for various properties. The materials are ranked by the highest value of their **typical** properties, the lowest typical value also being given. In some cases the form, temper, heat treatment or other condition of the material is given, particularly where such conditions markedly affect the value. More details on materials and conditions can be found in the other data sections.

Comparisons of Materials

Properties of Materials 37

Typical properties and uses of the important engineering materials. Most of the information is given in a standard tabular form, making comparison easy, and test conditions are summarized where known. A list of helpful suppliers' bulletins appears at the beginning of each section, and advertisements appear at the end of each section.

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Irons & Steels

Nonferrous Metals

Plastics & Rubber

Other Nonmetallics

Finishes & Coatings

Forms, Shapes & Composites 365

Data on the common forms (castings, moldings, etc.) of engineering materials and on composite materials (clad metals, laminates, etc.). Much of the information is in tabular form. A list of suppliers' bulletins appears at the beginning of the section, and advertisements of suppliers appear at the end.

Forms, Shapes & Composites

Joining & Fastening of Materials 469

Data on the joining and fastening methods used for engineering materials. A list of helpful bulletins available from suppliers appears at the beginning of the section, and advertisements of suppliers appear at the end.

Joining & Fastening

Suppliers of Materials 503

An alphabetical index to the important engineering materials and forms of materials, containing under each heading the names of the leading suppliers.

Suppliers of Materials

Addresses of Suppliers 562

An alphabetical list of the names and addresses of the suppliers of engineering materials and forms mentioned in the Directory.

Addresses of Suppliers

Materials
in Design Engineering

Application of metals, nonmetallics, forms, finishes

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How to Use the Materials Selector Issue

Naturally, you can use this issue in many different ways, depending upon the nature of your own materials problems. However, this issue is called the *Materials Selector Issue* because it is designed to help you systematically narrow your choice of materials, parts and finishes to meet a specific problem. Here is a logical procedure:

1. See Comparisons of Materials.
Look up the critical properties and see which materials warrant further investigation.

2. See Index to Data.

3. See Properties of Materials.*
Look up the pages indicated by the Index. Reduce the number of materials requiring further study by comparing significant properties, available forms, typical uses, and finishing and coating methods.

4. See Forms and Shapes of Materials.
Narrow the choice of materials further by comparing the characteristics of competitive forms and shapes.

5. See Joining and Fastening of Materials.
If assembly is required, limit choice of materials still further by comparing characteristics of competitive joining materials and processes.

6. See Suppliers of Materials.
Look up promising materials and forms to obtain the names of suppliers.

7. See Addresses of Suppliers.

8. Obtain detailed information
on properties, availability and cost of materials and fabricated forms by:

a. Writing to suppliers.

b. Consulting the Suppliers' Literature pages in Properties of Materials sections. Note key numbers of promising bulletins and circle them on one of the eight free post cards (pp 585-592).

c. Consulting the advertisements. Names of advertisers are bold faced in the Directory, and the pages on which their advertisements appear are indicated.

***WHAT THE DATA MEAN:**

Properties of Materials consists almost entirely of tabular data on the properties, forms and uses of engineering materials.

Tabular data on properties generally represent average test results obtained from many different sources and suppliers. Although the values may have been obtained from standard specified tests, in no case do the values represent minimum or maximum specified limits. A range of values may indicate either the normal variation encountered in that particular test, or the differences attributable to variations in the composition, temper, heat treatment, form, or other condition of the material. Where a value or range applies only to a particular condition of the material, the condition is stated.

Available forms listed in these sections are the most important forms that are readily available commercially. Uses listed in these sections are only typical and are not intended to be exhaustive.

These data have a limited purpose. Space does not permit a complete description of the materials and test conditions to which the data apply; hence, these data cannot be used directly for final designs. They are intended solely to aid in the important job of materials selection.

Stress-Rupture Strength of High Temperature Alloys

1000 Hr

1200 F		1350 F		1500 F		1600 F		1700 F		1800 F	
Alloy	Stress, 1000 psi	Alloy	Stress, 1000 psi	Alloy	Stress, 1000 psi	Alloy	Stress, 1000 psi	Alloy	Stress, 1000 psi	Alloy	Stress, 1000 psi
René 41	102	Inconel 713C[a]	70	Inconel 713C[a]	41	Udimet 700	29	Inconel 713C[a]	17.5	Molybdenum[c]	44
Udimet 700	101	Udimet 500	67.5	1753	34	Inconel 713C[a]	28	X-40[a]	14.5	Columbium[c]	25
1753	98	Inconel 700	59	Udimet 500	32	1753	22	1753	12	X-40[a]	9.8
Udimet 500	94	Waspaloy	52	Inconel 700	31	Udimet 500	20.5	René 41	11	Inconel 713C[a]	9
U-212	88	W-545	50	GMR-235[a]	29	GMR-235[a]	18	HS-21[a]	10	HS-21[a]	7
Inconel 700	87	D979	47	René 41	29	X-40[a]	18	Inconel 700	8.6	S-816	6.5
Waspaloy	86	GMR-235[a]	47	Waspaloy	26.5	René 41	17	HS-25	8.4	1753	6.5
D979	79	M-252	43	X-40[a]	23.5	Waspaloy	16.5	Hastelloy C[a]	6.0	HS-25	5
M-252	79	U-212	42.5	M-252	22.5	Inconel 700	16	N-155	4.8	HT[a]	3.7
Inconel X	68	Inconel X	40	D979	22	M-252	13.5	HT[a]	4.7	Hastelloy X	3
W-545	66	S-816	40	S-816[a]	21	HS-21[a]	13.4	HH[b]	3.9	HK[a]	3
Refractaloy 26	63	X-40[a]	39	S-816	19	S-816[a]	13	HK[a]	3.8	Hastelloy X[a]	2.9
Incoloy 901	62	Refractaloy 26	38	Inconel X	18	HS-25	12	Inconel 702[b]	3.5	N-155	2.6
HS-25	54	HS-25	34	Refractaloy 26	18	Refractaloy 70	10			HH[a]	2.5
S-816	51	Incoloy 901	30	HS-25	17	S-816	10			Inconel 702[b]	2.4
X-40[a]	51	S-816[a]	29	N-155	16	Hastelloy C[a]	9.2				
N-155[a]	47	Hastelloy B[a]	25.5	S-590	16	S-590	9.0				
A-286	46	Hastelloy C[a]	25	Refractaloy 70	15	N-155	7.2				
HS-21[a]	44.2	S-590	25	Hastelloy C[a]	14.5	Hastelloy X	7				
S-816[a]	44	N-155[a]	24	HS-21[a]	14.2	Inconel X	7				
Hastelloy C	43	Refractaloy 70	24	N-155[a]	14	Inconel 702[b]	5.1				
N-155	43	Hastelloy C	23	Hastelloy B[a]	12.7						
Nivco	43	HS-21[a]	22	Hastelloy C	12.5						
Hastelloy C[a]	42.5	N-155	22	Incoloy 901	11						
Refractaloy 70	42	A-286	21	Hastelloy X	10						
Discaloy	41	16-25-6	21	V-36[c]	10						
Inconel 702[b]	41	Inconel 702[b]	20	HT[a]	9.2						
Hastelloy B[a]	40.5	19-9DL	19	Hastelloy X[a]	9.1						
S-590	38	Hastelloy X	18.5	16-25-6	9						
19-9DL	37	V-36[c]	18	19-9DL	9						
Hastelloy B	36.5	Hastelloy B	17	Inconel 702[b]	8.8						
16-25-6	34	Hastelloy X[a]	16	HH[a]	8.2						
Hastelloy X	33	HT[a]	15.2	A-286	7.7						
V-36[c]	30	HH[a]	14.9	HK[a]	7						
Hastelloy X[a]	26.5	HF[a]	12	HF[a]	6.5						
HH[a]	26.5	HK[a]	11								
HT[a]	25										

[a] Cast. [b] Estimated. [c] Sheet. [d] Annealed or recrystallized. [e] Stress relieved.

10,000 Hr

1200 F		1350 F		1500 F		1600 F	
Alloy	Stress, 1000 psi	Alloy	Stress, 1000 psi	Alloy	Stress, 1000 psi	Alloy	Stress, 1000 psi
Waspaloy	67	U-500	46	U-500	24	Waspaloy	11
M-252	64	Waspaloy	39	Waspaloy	17.5	M-252	8.2
S-816	40	M-252	33	S-816	16	S-816	7.5
N-155	35	S-816	24	M-252	14	HT	4.9
A-286	32	N-155	17	N-155	11.5	HH	3.9
19-9DL	31	19-9DL	12.5	HT	6.9	HK	3.8
HH, HT	20	HT	11.5	HH	6.0		
				19-9DL	5.6		
				HK	4.7		

Effect of Radiation on Materials

EFFECT ON TENSILE PROPERTIES OF METALS

Metal ↓	Condition of Metal	Irradiation		Yield Strength		Tensile Strength		Elongation	
		Temp, F	Integrated Fast Neutron Flux, n/sq cm	Unirrad, 1000 psi	Change After Irrad, 1000 psi	Unirrad, 1000 psi	Change After Irrad, 1000 psi	Unirrad, %	Change After Irrad,* %
CARBON STEELS									
ASTM A212B	Normalized at 1904 F	176	10^{19}	51	14.4	75	6.8	23	−5
ASTM A212B	Same as Above	176	10^{20}	51	42	75	25	23	−18
ASTM A302B		500	3.7×10^{18}	65	7.1	91.5	3.8	26	−2
ASTM A302B		698	3.7×10^{18}	64.2	3.3	89.8	2.8	27	−1
STAINLESS STEELS									
347			2.6×10^{22}	61.6	39.2	95.8	11.4	63.2	19.2
316	Annealed	104	5×10^{20}	—	—	79	71	—	—
440 C	Hardened		5×10^{19}	185	18	205	35	—	—
301		176	4×10^{19}	38.4	48.6	98.7	14.5	56	−8
304 ELC		176	8×10^{19}	24.4	51.1	86.3	17.5	63	−5
302		176	4×10^{19}	33.9	50.1	95.5	15.8	—	—
302 B		176	4×10^{19}	33.5	48	107.8	17.2	—	—
305		176	4×10^{19}	32.1	39.3	98	5.6	—	—
347		176	4×10^{19}	37	59.5	97.6	17.2	49	−24
321		176	8×10^{19}	31.2	59.4	84.8	21	—	—
410	Annealed		10^{20}	147.7	35.1	177	24	20	−5
ALUMINUM ALLOYS									
1100			2.6×10^{22}	18.4	8.1	20.3	10.1	22.3	0.7
356			2.6×10^{22}	24.1	11.9	32.4	12.6	2.7	−1.2
1100-O		149	10^{20}	6.8	10.3	13.6	12.4	38.2	−17
1100-H14		149	10^{20}	16.6	7.4	17.3	8.7	6	−0.5
6061-O		149	10^{20}	9.5	16.1	18.1	19.2	28.8	−6.4
6061-T6		149	10^{20}	38.5	5.9	45	5.6	17.5	−1.3
NICKEL ALLOYS									
Monel	As Received	104	4×10^{19}	—	—	85	11	33	−23
K Monel	As Received	104	4×10^{19}	—	—	123	11	11	−8
Inconel	As Received	104	4×10^{19}	—	—	106	10	31	−2
Inconel X	As Received	104	4×10^{19}	—	—	126	7	37	−14
Hastelloy C	Cast		4×10^{19}	—	—	80	27	—	—
Hastelloy C	Wrought	104	4×10^{19}	—	—	138	4	20	−8
Hastelloy X	Annealed		5×10^{19}	49.4	50.8	112.5	16.8	52	−2
Inconel 702	Annealed		5×10^{19}	42.6	58.5	94.9	18.2	67	−17
Inconel X	Aged Once		2×10^{20}	120.3	50.5	184.3	−10.3	23	−10
K Monel	Annealed		5×10^{19}	132.4	35.2	163.4	5.3	22	−10
OTHER METALS									
Copper	Annealed	212	5×10^{19}	8.4	21.9	27.1	7.2	42.2	−14.7
Nickel	Annealed	212	5×10^{19}	36.2	25.3	58.6	4.3	34.4	−11
Molybdenum	Stress Relieved	212	5×10^{19}	93.7	5.7	99.8	4.5	23.6	−1.6
Tungsten	Fully Recrystallized	212	5×10^{19}	—	—	137	15	0	0
Titanium	Annealed	212	5×10^{19}	79.8	8.9	83.4	8.8	10.4	−2.1
Zirconium	Heavily Cold Worked	212	5×10^{19}	107	−1	123.5	0.8	3.5	0.7
Tungsten	As Received		5×10^{19}	—	—	153	−36	0	0
Tantalum	As Received		5×10^{19}	—	—	68	19	21	−4
Stellite 3	As Received		5×10^{19}	—	—	86	8	—	Low
Zircaloy 2	Annealed	122	10^{21}	44.1	25.9	68.4	11.6	23	−8
Zircaloy 2	50% Cold Worked	122	1×10^{21}	79.6	24.9	98.3	16.2	19.5	−10.3
QMV Beryllium			7×10^{21}	24.5	—	35.7	14.7	1.4	−1.2
Zirconium	Annealed	158	2×10^{20}	34.5	21.6	64.1	7.1	33	−11
Zirconium	50% Cold Worked	158	2×10^{20}	83.7	10.8	86.7	9	11	−4

* All changes are plus unless otherwise indicated.

EFFECT ON HARDNESS OF METALS

Metal ↓	Condition of Metal	Irradiation		Brinell Hardness	
		Temp, F	Integrated Fast Flux, n/sq cm	Unirrad	Change After Irrad[a]
PLAIN CARBON STEELS					
1018	Annealed	104	10^{19}	138	23
1018	Hardened	104	10^{19}	237	6
1042	Annealed	104	10^{19}	225	−38
1042	Hardened	104	10^{19}	390	36
1045	Annealed	104	10^{20}	187	0
1095	Annealed	104	10^{19}	290	25
1095	Hardened	104	10^{19}	535	0
STAINLESS STEELS					
410	Annealed		3×10^{20}	318	10
16-1 Croloy	Annealed		8×10^{19}	159	57
347 C	Annealed	203	10^{20}	—	82
304	Surface Nitrided	104	5×10^{20}	654	156
316	Annealed	104	5×10^{20}	154	74
410	Surface Nitrided	104	5×10^{20}	656	84
440 C	Hardened	104	5×10^{20}	545	0
440 C	Hardened		4×10^{19}	461	73
USS "W"	Hardened	104	5×10^{20}	461	0
NICKEL ALLOYS					
Hastelloy C	Cast		5×10^{19}	228	132
Hastelloy C	Wrought	104	4×10^{19}	209	0
Monel	Annealed	104	4×10^{19}	150	59
K Monel	As Received	104	4×10^{19}	260	25
Inconel	As Received	104	4×10^{19}	175	65
Inconel X	Annealed	104	4×10^{19}	209	56
Hastelloy X	Annealed		5×10^{19}	172	44
Inconel 702	Annealed		5×10^{19}	156	60
Inconel X	Aged Twice		10^{19}	265	21
Inconel X	Aged Once		10^{19}	301	17
K Monel	Annealed		5×10^{19}	271	9
OTHER METALS					
Copper[b, c]		194	5×10^{20}	44	56
Nickel[b, c]		194	5×10^{20}	61	55
Titanium (75A)[c]		194	5×10^{20}	177	33
Zirconium[b, c]		194	5×10^{20}	69	21
Iron[b, c]		194	5×10^{20}	53	42
Molybdenum[c]		194	5×10^{20}	204	23
1100 Aluminum			2×10^{21}	38	34
1100 Aluminum			3×10^{22}	38	38
356 Aluminum			2×10^{21}	67	29
QMV Beryllium			2×10^{21}	127	52
Stellite 3			5×10^{19}	420	55
Tungsten			5×10^{19}	—	0
Tantung G			5×10^{19}	—	0
Tantalum			5×10^{19}	147	53

[a] All changes are plus unless otherwise indicated.
[b] High purity. [c] Annealed.

EFFECT ON IMPACT PROPERTIES OF METALS

Metal ↓	Irradiation		Change in Transition Temp, °F[a]
	Temp, F	Integr Fast Neutron Flux, n/sq cm	
FERROUS METALS			
Iron	527	10^{20}	Increase
ASTM A302B Steel[b, c]	500	4×10^{18}	11
Same as Above	698	4×10^{18}	11
ASTM A212B Steel[d]	176	10^{19}	9
Same as Above	176	10^{20}	103
ASTM A212 Steel[f]	122	10^{20}	151
ASTM A212 Steel	428	2×10^{18}	34
ASTM A212 Steel	572	2×10^{18}	45
NONFERROUS METALS			
Tungsten[e]	212	5×10^{19}	14
Molybdenum	212	5×10^{19}	185
Zirconium	104	5×10^{19}	Small
Aluminum	527	10^{20}	Decreases
Copper	527	10^{20}	Increases
Nickel	527	10^{20}	Increases

[a] Numerical changes indicated are positive.
[b] Normalized at 1650 F. [c] Standard V-notch Charpy.
[d] Normalized at 1900 F. [e] Subsize Izod.
[f] Subsize notched cylinders. [g] Subsize tension test.

EFFECT ON DENSITY OF METALS

Material ↓	Irradiation	Density	
	Integr Fast Neutron Flux, n/sq cm[a]	Unirrad, lb/cu in.	Change After Irrad, %[b]
1100 Aluminum	240	0.0978	−0.004
356 Aluminum	240	0.0962	−0.02
QMV Beryllium	240	0.0665	0
347 Stainless Steel	240	0.285	−0.003
316 Stainless Steel	3.5	0.288	−0.06
347 Stainless Steel	3.5	0.286	−0.09
347+Ta Stainless Steel	3.5	0.286	−0.04
410 Stainless Steel	3.5	0.277	−0.05
"A" Nickel	3.5	0.321	−0.07
Monel	3.5	0.319	−0.05
Stellite 3	3.5	0.309	0.06
Stellite 6	3.5	0.301	0.11
ASTM A212 Steel	3.5	0.283	0
Tantalum	5	—	−0.10
Tungsten	5	—	−0.15
Tantung G	5	—	−0.20 to −0.25
WC-Co, TAC-Co	8	—	−0.3 to −0.6
TiC-Ni	8	—	−0.3 to −0.6

[a] 104 F. [b] All changes are plus unless otherwise indicated.

continued on page 34

Effect of Radiation on Materials

EFFECT ON CERAMICS AND ALLIED MATERIALS

Material	Exposure	Effects
CERAMIC OXIDES		
Al_2O_3[a]	2 x 10^{20} n/sq cm	No chg in x-ray pattern and ther cond. Some color chg
BeO[b]	2 x 10^{20} n/sq cm	0.3% exp in c_o, none in a_o as det by x-ray pattern. No chg in ther cond
MgO[c]	2 x 10^{20} n/sq cm	No chg in basic lattice. Single crystal broken into reactive small crystals
Quartz	10^{21} n/sq cm	Decr in density to 2.25. Chg in axial ratio (c/a) from 4.1 to about 1.06. Signif energy release shown by DTA at 1110 F
SiO_2	10^{21} n/sq cm	Decr in density to about 2.25 (17.7% chg). No macroscopic defects or loss of structure. Color chg
SiO_2[d]	2 x 10^{20} n/sq cm	Incr in density to 2.25. Heating at red heat removes increase. Color chg to deep violet or dark brown
SiO_2[d]	2 x 10^{10} ergs/gm (C), electrons	Highly purified silica shows no discolor. Comm silica appears dark, mottled
TiO_2[e]	2 x 10^{20} n/sq cm	No chg in x-ray pattern. Slight decr in ther cond. Color chg
ZrO_2[e]	2 x 10^{20} n/sq cm	Rad-induced phase chg, monoclinic to cubic. No chg in cubic lattice. Slight decr in ther cond
MISCELLANEOUS CERAMICS		
Spinel, Forsterite, Porcelain, Steatite	2 x 10^{20} n/sq cm	No chg in crystal structure. Decr in ther cond (factor of 2). Color chg
Cordierite	2 x 10^{20} n/sq cm	Loss of crystallinity. Decr in ther cond (factor of 4). Color chg
Zircon	1 x 10^{20} n/sq cm	1.9% exp. Large loss of crystallinity
Zircon	2 x 10^{20} n/sq cm	Complete loss of crystallinity. Decr of ther cond (factor of 5). Color chg
$BaTiO_3$	2 x 10^{20} n/sq cm	2.87% exp in a_o. Marked color chg
Mica (muscovite)	10^9 ergs/gm (C), gamma	No effects noted

[a] Effects noted on both single crystals and hot pressed materials.
[b] Hot pressed. [c] Single crystal.
[d] Vitreous. [e] Polycrystalline, sintered.

EFFECT ON GLASS

Glass Type	Type of Radiation or Dosage	Property Change
PHOSPHATE GLASSES		
K-Ba-Al Phosphate	Gamma	Colors easily
Ca Metaphosphate	Gamma	Abs peak near 4700 A
Silver (activated)	Gamma	Abs near UV
Lead-Containing (60% w/o PbO)	10^{14} n/sq cm	No discolor, melts
SPECIAL GLASSES		
Pure GeO_2 Glass	Gamma	Insensitive at 10^5–10^9 ergs/gm (C)
1 PbO–1.3 P_2O_5	2 x 10^{20} n/sq cm	Slight discolor
1 PbO–1.22 V_2O_5	2 x 10^{20} n/sq cm	No signif chg
1 PbO–1.5 SiO_2	2 x 10^{20} n/sq cm	Chg from yellowish clear to amber clear; considerable decr in hardness
0.8K_2O–0.2CaO–2.75 SiO_2	2 x 10^{20} n/sq cm	Chg from colorless to gray
$Li_2O \cdot 3B_2O_3$, $Na_2O \cdot 2B_2O_3$, K_2O–$2B_2O_3$, $Rb_2O \cdot 2B_2O_3$	3 x 10^{10} ergs/gm (C), gamma	Abs 10 times greater than for fused B_2O_3
OTHER GLASSES		
Lead Glass (window)	Gamma	May develop brown color
Soft Glass	5.8 x 10^{19} n/sq cm	Dark color, slight incr in ten str; decr in impact str
Optical Glass (crown and flint)	10^6–10^8 ergs/gm (C)	Develops color at 10^6 ergs/g (C) or less; useless at 10^8 ergs/gm
Optical Glass (protected; cont 1-2% CeO_2)	X-ray or gamma	No color at 10^8 ergs/g (C); usable at 5 x 10^{10} ergs/gm (C)
Soda-Lime-Silica Glass (cont cobalt)	Gamma	Color chg sensitive to dosage; suitable for dosimeter
Fused Silica		
General	All types of high-energy rad	Color centers form; abs band at 214 mμ
Pure	Fast neutrons	Density may chg from 2.2 to 2.27
	10^{11} ergs/gm (C), gamma	No chg in abs
	Reactor, gamma	Intense abs band at 218 mμ
With Al Impurity	X-ray, UV	Develops abs bands at 5500, 2950 and 2150 A
Borosilicate	10^{20} n/sq cm	Develops large cracks
Pyrex (borosilicate)	5.8 x 10^{19} n/sq cm	Color darkens; slight incr in ten and impact str

EFFECT ON PLASTICS LAMINATES

Material	Irradiation			Tensile Strength, psi		Flexural Modulus, 10^6 psi	
	Exposure, ergs/gm (C)	Temp, F	Exp Time, hr	Unirrad, 1000 psi	Chg After Irrad, 1000 psi	Unirrad	Chg After Irrad
Silicone (flexure test)	8.5×10^9	Room	200	31.7	−0.3	3.06	−0.12
	2×10^9	500	50	12.4	+1.2	1.9	+0.10
	4×10^9	500	100	13.4	−1.7	2.0	0
	8.5×10^9	500	200	14.1	−4.2	2.0	−0.1
Heat Resistant Epoxy (compression test)	8.5×10^9	Room	200	46.7	0	—	—
	2×10^9	500	50	3.7	+0.1	—	—
	4×10^9	500	100	4.1	+1.3	—	—
	8.5×10^9	500	200	4.7	+1.6	—	—
Phenolic (flexure test)	8.5×10^9	Room	200	84.5	−0.5	4.2	+0.1
	2×10^9	500	50	27.3	+27.7	3.1	+0.3
	4×10^9	500	100	17.7	+24.3	2.6	+1.0
	8.5×10^9	500	200	12.3	+3.3	2.1	+0.3

EFFECT ON PLASTICS AND RUBBER MATERIALS[a]

Material ↓	Beginning of Moderate Damage, ergs/gm (C)[b]	Beginning of Serious Damage, ergs/gm (C)
PLASTICS MATERIALS		
Phenolic Laminates	$>10^{12}$	$>10^{12}$
Polystyrene	7.5×10^{10}	6.5×10^{11}
Polyester Laminates	7.5×10^{10}	5.5×10^{11}
Phenolics, Mineral-Filled	5×10^{10}	5×10^{11}
Silicones, Glass-Reinforced	5×10^{10}	5×10^{11}
Epoxy Resins	10^{10}	9×10^{10}
Phenolics, Unfilled	4.5×10^9	3×10^{10}
Polyvinyl Chloride	4.5×10^9	5×10^{10}
Amino Resins	2×10^9	9×10^9
Polyethylene	10^9	9×10^9
Cellulosics	8×10^8	5×10^9
Silicones	10^8	4.5×10^9
Polyamides	10^8	10^9
Polyesters, Unfilled	10^8	2.5×10^8
TFE Fluorocarbon	5×10^6	2.5×10^7
RUBBER MATERIALS		
Urethane	7.5×10^9	4.5×10^{10}
Natural	6×10^9	3×10^{10}
SBR	3.5×10^9	3×10^{10}
Nitrile	2×10^9	9.5×10^9
Neoprene	2×10^9	9.5×10^9
Acrylic	0.5×10^9	10^{10}
Silicone	8×10^8	6×10^9
Fluoroelastomers	8×10^8	4×10^9
Polysulfide	1.5×10^8	4.5×10^8
Butyl	0.5×10^8	4×10^8

[a] Estimated from graph.
[b] Incipient to mild damage at about $10^5 - 10^7$ ergs/gm (C).

SUPPLIERS' LITERATURE

Irons and Steels

Stainless Steel. Allegheny Ludlum Steel Corp., 18 pp, No. FS57. Information on grades of stainless steel; various forms of corrosive attack; resistance of stainless steel to various corrosive media; comparative physical, mechanical and other properties; fabrication data; available forms; and other information necessary for selecting stainless steels. **1**

Manganese Steel. American Manganese Steel Div., American Brake Shoe Co., 16 pp, illus., No. 2. Information on the use of manganese steel for hard facing and for construction equipment. **2**

Oriented Electrical Steels. Armco Steel Corp., 4159 Curtis St., Middletown, Ohio, 64 pp, illus. Classification; advantages; physical, mechanical and magnetic properties; surface preparation; and other technical data on a line of oriented electrical steels. Write on company letterhead directly to Armco.

Tool Steel Selector. Bethlehem Steel Co., 14 pp, No. 513. General descriptions of the five basic groups of tool steels, typical analyses and properties, and a selection guide consisting of recommended tool steels for typical applications. Included are specifications, sizes, and instructions for ordering. **3**

Corrosion of Wrought Iron. A. M. Byers Co., 12 pp. Results of eight-year corrosion tests on wrought iron and 10 structural steels in salt water and lake water environments. Included are comparative corrosion-time curves, weight loss tables and complete details on test materials, conditions, methods and results. **4**

Stainless Steel Services. G. O. Carlson, Inc., 12 pp, illus. Information on stainless steel plates, heads, forgings, rings, circles, flanges, bars, and sheets used in the metalworking, chemical process, nuclear, and aircraft and missile industries. **5**

Specialty Steels. Carpenter Steel Co., 40 pp, illus. Properties and uses of tool and die steels, stainless steels, high temperature alloys, electronic, magnetic and electrical alloys, special purpose alloy steels, tubing and pipe, and fine wire specialties. **6**

Stainless Steels. Cooper Alloy Corp., 10 pp, illus. Composition ranges, mechanical properties, corrosion resistance and high temperature mechanical properties of molybdenum-containing 18-8 type stainless steels. **7**

Electric Furnace Steels. Copperweld Steel Co., Artistoloy Steel Div., 48 pp, illus. Facilities for melting, rolling, finishing, heat treating and conditioning electric furnace steels. Rolling limits and chemical analyses are also given. **8**

Boron Stainless Steel. Superior Steel Div., Copperweld Steel Co., 8 pp, illus., No. 57. Chemical composition, microstructure, corrosion resistance, machinability and mechanical properties of a boron stainless steel. **9**

Data on Steel. Crucible Steel Co. of America, 73 pp, illus. Composition, heat treatment, and weight and conversion tables for tool, stainless, heat resisting, carbon, alloy, and special purpose steels. **10**

Titanium-Bearing Stainless Steels. Eastern Stainless Steel Corp., 4 pp, illus., No. 102. Information on a new flux casting method that reduces inclusions in titanium-bearing stainless steels. **11**

Stainless Steel Specifications. Peter A. Frasse & Co., Inc., Sec. A, No. 1. Chart provides chemical compositions and nearest SAE and AMS designations for 40 standard AISI grades of stainless steel and 18 special grades, including precipitation hardening stainless steels. **12**

Tool Steels. Jessop Steel Co., 14 pp, illus. Information on cast-to-shape air hardening, oil hardening, hot worked, flame hardening, stainless and heat resisting tool steels. **13**

Stainless Steel Wire. Jones & Laughlin Steel Corp., Stainless & Strip Div., 22 pp, illus. Technical data and other information on how to use and order stainless steel wire. **14**

Steel Analyses. Jones & Laughlin Steel Corp., Stainless & Strip Div., 20 pp. Compositions, and SAE, AISI and AMS numbers for 40 stainless steels, 184 alloy steels and 105 carbon steels. **15**

High Strength Steel Bar. LaSalle Steel Co., 10 pp, illus., No. 15. Advantages, characteristics, properties, typical applications and other information on copper-containing high strength steel bar. **16**

High Strength Steel. Latrobe Steel Co., 4 pp, illus. Composition, physical and mechanical properties, specifications and applications of a machinable high strength steel. **17**

Steel Plate Shapes. Lukens Steel Co., 16 pp, illus., No. 378. Information on facilities for flame cutting, shearing, blanking, punching, pressing, bending, and welding various shapes made from steel plates. **18**

Zinc-Coated Steel. Weirton Steel Co., Div. of National Steel Corp., 12 pp, illus. Installation data, specifications, uses and characteristics of zinc-coated steel. **19**

Coated Steel Strip. Thomas Strip Div., Pittsburgh Steel Co., 20 pp, illus. Actual samples of strip steel electrolytically coated with zinc, copper, brass, lead alloy, nickel and chromium, in natural and buffed finishes. **20**

Stainless Steel. Republic Steel Corp., 12 pp, illus., May-June '60. Advantages, characteristics, properties, and other data on stainless steel. **21**

Steel Services. Joseph T. Ryerson & Son, Inc., 256 pp, illus., No. 117. Reference book lists types, shapes and sizes of steel, aluminum, and industrial plastics available for immediate shipment from stock. **22**

Spring, Strip, Specialty Steels. Sandvik Steel, Inc., 6 pp, illus. Sizes, materials and chemical composition of spring and specialty strip steels. **23**

Steel Catalog. Timken Roller Bearing Co., 16 pp, illus., No. L758. General information, advantages, and other data on alloy steel bars and billets, stainless steel bar, tool steels and seamless steel tubing. **24**

High Temperature Steels. United States Steel Corp., 88 pp, illus. Discusses the nature of creep, measurement of flow under stress at elevated temperature, factors affecting high temperature properties, and behavior of steels at elevated temperatures. Includes specifications, heat treatment, composition, tensile properties, creep and rupture properties, and effect of time and temperature on impact strength and hardness of 21 different high temperature steels. **25**

Steel Strip. American Steel & Wire Co., Div. of U. S. Steel Corp., 48 pp, illus. Physical properties, dimensions, tempers and finishes of cold rolled stainless and carbon steel strip. **26**

Stainless Wire. Universal-Cyclops Steel Corp., 4 pp, illus., No. SS-200. Information on cost, corrosion resistance and cold heading characteristics of commonly used stainless steel cold heading wire. **27**

Cr-Mo-V Steel. Vanadium Corp. of America. Chemical composition, creep strength, stress rupture strength, and resistance to graphitization of a chromium-molybdenum-vanadium steel. **28**

Superalloy Casting Alloy. WaiMet Alloys Co., 4 pp, illus. Stress rupture properties, mechanical properties, chemical composition, and other technical data on a superalloy casting alloy. **29**

Stainless Steel. Washington Steel Corp., 32 pp, illus. Physical properties, composition, fabrication, corrosion and heat resistance, and cleanability of special purpose stainless steel sheet and strip. **30**

Galvanized Sheet Steel. Wheeling Steel Corp., 44 pp, illus. Properties and uses for galvanized steel sheet and strip called Softite. **31**

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PROPERTIES OF MATERIALS

Irons and Steels

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Gray Irons—Cast

Class[a] →	20	25	30
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.26	0.26	0.26
Thermal Conductivity (212 F), Btu/hr/sq ft/°F/ft.	24–34	24–34	24–34
Coef of Ther Exp (32–212 F), per °F.	6×10^{-6}	6×10^{-6}	6×10^{-6}
Magnetic?	Yes	Yes	Yes
Electrical Resistivity (68 F), microhm-cm.	Varies from 50 to 200 depending on composition		
MECHANICAL PROPERTIES[b]			
Mod of Elast in Tension, psi[c]	13, 12, 9×10^6	14, 13, 11.5×10^6	16, 15, 13.5×10^6
Tensile Strength (as cast), 1000 psi.	24–29, 20–24, 15–19	27–33, 25–30, 20–24	35–40, 30–34, 20–24
Transverse Strength (as cast), 1000 lb[d]	1, 2, 5.2	1.25, 2.1, 5.5	1.4, 2.2, 7.3
Deflection (as cast), in.[d]	0.14, 0.25, 0.25	0.17, 0.27, 0.30	0.16, 0.28, 0.31
Modulus of Rupture (as cast), 1000 psi.	50, 53, 40	57, 56, 42	63, 58, 56
Hardness (Brinell, as cast)[e]	200, 180, 170	205, 190, 175	210, 200, 180
Fatigue Strength (endurance limit, as cast), 1000 psi[f]	—, 10, —	—, 12.5, —	—, 14.5, —
Compressive Strength (as cast), 1000 psi[g]	100, 95, 90	—, 100, —	—, 115, —
Shear Strength (as cast), 1000 psi.	—, 32, —	—, 37, —	—, 44, —
FABRICATING PROPERTIES	Gray cast iron, having a ferrite matrix in which graphite flakes are dispersed, has a machinability rating of 110. When a cast iron microstructure shows alloy segregation, free carbides, steadite and free pearlite, machinability is reduced and may be as low as 40. Some castings show several structures due to cooling rate and section size		
JOINING	Can be joined by gas welding; shielded metal-arc welding using special electrodes; carbon arc welding. Preheating necessary. Can be brazed with nonferrous filler metal		
CORROSION RESISTANCE	More resistant to some types of corrosion than carbon and low alloy steels, possibly because of graphite; cast iron soil pipe usually lasts longer than steel pipe, for example. Gray irons are resistant to strong sulfuric acid, cold concentrated phosphoric and nitric acids; attacked by dilute sulfuric, phosphoric and nitric acids. Resistant to many alkalis, including sodium hydroxide, soda ash and ammonia		
USES	Machine bases, grates, housings, ornamental castings, sanitary wear, piston rings, pipe and fittings	Similar to class 20 where higher strength is required	Light brake drums, clutch plates, cylinder blocks, liners, impellers, pipe and fittings, grate bars, machine parts

[a] Specified min tensile strength, 1000 psi, ASTM A48-48.
[b] Three values are given for light, medium and heavy sections, respectively.
[c] At ¼ max transverse load.
[d] Bar diameters 0.875, 1.2 and 2.0 in., respectively. Distance between supports 12, 18 and 24 in., respectively.
[e] Considerably wider range obtainable by heat treatment.
[f] About 40% of tensile strength appears to be safe level for endurance limit.
[g] In general, compressive strength is three to five times tensile strength.

Gray Irons—Cast

Class[a] →	35	40	50	60
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.26	0.26	0.26	0.26
Ther Cond (212 F), Btu/hr/sq ft/°F/ft.	24–34	24–34	24–34	24–34
Coef of Ther Exp (32–212 F), per °F	6×10^{-6}	6×10^{-6}	6×10^{-6}	6×10^{-6}
Magnetic?	Yes	Yes	Yes	Yes
Elec Res (68 F), microhm-cm	Varies from 50 to 200 depending on composition			
MECHANICAL PROPERTIES[b]				
Mod of Elast in Tension, psi[c]	17, 16, 14.5 x 10^6	18, 17, 15.5 x 10^6	19, 19, 18 x 10^6	20, 19.5, 19 x 10^6
Ten Str (as cast), 1000 psi	38–42, 35–40, 25–33	50, 40–48, 33–45	60, 50–57, 52	70, 60–66, 50–75
Transverse Str (as cast), 1000 lb[d]	1.5, 2.6, 8	1.75, 2.9, 10	2, 3.3, 10.7	2.5, 3.7, 15
Deflection (as cast), in.[d]	0.17, 0.28 –	0.16, 0.28, 0.30	0.18, 0.28, 0.30	0.13, 0.34, 0.40
Mod of Rupture (as cast), 1000 psi	70, 69, 63	80, 78, 76	91, 88, 82	114, 98, 115
Hardness (Brinell, as cast)[e]	220, 210, 190	230, 220, 210	260, 240, 230	300, 290, 275
Fatigue Str (endur limit, as cast), 1000 psi[f]	–, 17.5, –	–, 21, –	–, 25, –	–, –, –
Compr Str (as cast), 1000 psi[g]	150, 125, –	–, 143, –	–, 150, –	–, 170, –
Shear Str (as cast), 1000 psi	–, 43, –	–, 57, –	–, –, –	–, –, –
FABRICATING PROPERTIES	Gray cast iron, having a ferrite matrix in which graphite flakes are dispersed, has a machinability rating of 110. When a cast iron microstructure shows alloy segregation, free carbides, steadite and free pearlite, machinability is reduced and may be as low as 40. Some castings show several structures due to cooling rate and section size			
JOINING	Can be joined by gas welding, shielded metal-arc welding using special electrodes, carbon arc welding. Preheating necessary. Can be brazed with nonferrous filler metal			
CORROSION RESISTANCE	More resistant to some types of corrosion than carbon and low alloy steels, possibly because of graphite; cast iron soil pipe usually lasts longer than steel pipe, for example. Gray irons are resistant to strong sulfuric acid, cold concentrated phosphoric and nitric acids; attacked by dilute sulfuric, phosphoric and nitric acids. Resistant to many alkalis, including sodium hydroxide, soda ash and ammonia			
USES	Clutch plates, crankcases, light brake-drums, liners, sleeves, cylinder blocks, impellers, machine components	Gears, camshafts, heads, liners, valves, pumps, tube supports, dies, wheels	Gears, valves, heads, blocks, steam pressure castings, dies, compressors, pumps, rams	Special brake drums, pressure castings, crusher frames, hot forming dies, heavy duty gears, hydraulic cylinders

[a] Specified min tensile strength, 1000 psi, ASTM A48-48.
[b] Three values are given for light, medium and heavy sections, respectively.
[c] At $\frac{1}{4}$ max transverse load.
[d] Bar diameters 0.875, 1.2 and 2.0 in., respectively. Distance between supports 12, 18 and 24 in., respectively.
[e] Considerably wider range obtainable by heat treatment.
[f] About 40% of tensile strength appears to be safe level for endurance limit.
[g] In general, compressive strength is three to five times tensile strength.

Nodular or Ductile Irons—Cast

Type ➡	80-60-3	60-45-10	100-75-04[a]
COMPOSITION, %	T.C. 3.3-3.8, Si 2.0-3.0, Mn 0.2-0.5, P 0.06-0.08, Ni 0-1.0, Mg 0.02-0.07	T.C. 3.4-4.0, Si 2.0-2.75, Mn 0.2-0.6, P 0.06-0.08, Ni 0-1.0, Mg 0.02-0.07	T.C. 3.4-3.8, Si 2.0-2.75, Mn 0.3-0.6, P 0.08 max, Ni 0-2.5, Mo 0-1.0, Mg 0.02-0.07
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.257	0.257	0.257
Melting Temp Range, F	2050-2150	2050-2150	2050-2150
Thermal Conductivity (212 F), Btu/hr/sq ft/°F/ft	18	20	—
Coef of Ther Exp (70-400 F), per °F	6.6×10^{-6}	6.6×10^{-6}	6.6×10^{-6}
Electrical Resistivity (75 F), microhm-cm	68[b]	66[b]	—
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	$22\text{-}25 \times 10^6$	$22\text{-}25 \times 10^6$	$22\text{-}25 \times 10^6$
Tensile Strength, 1000 psi	90-110	60-80	100-120
Yield Strength, 1000 psi	60-75	45-60	75-90
Elongation (in 2 in.), %	3-10	10-25	6-10
Hardness (Brinell)	200-270	140-190	200-240
Impact Strength (Charpy), ft-lb			
Unnotched	15-65	60-115	35-50
Notched	2-5	10-15	—
Fatigue Strength	Endurance ratio follows pattern of other ferrous materials. For soft ferritic materials, notched endurance ratio is about 50-55%; with stronger irons, the ratio drops to 30-40% or lower		
Compressive Strength	Ratio of compressive strength to tensile strength is about 2 to 1		
Creep Strength (0.0001%/hr), psi			
800 F	19,000	14,000	—
1000 F	1,750	4,000	—
1200 F	480	550	—
1400 F	—	—	—
THERMAL TREATMENT			
Ferritic Structure (ferritizing anneal)	Heat in 1600-1650 F range, cool to 1300 F, hold 1-3 hr, furnace cool to 1100 F, air cool		
Pearlitic-Ferritic Structures	Heat to 1600-1650 F, cool rapidly, reheat at 1100-1300 F		
Pearlitic Structures	Normalize by air cooling from 1600-1650 F		
Tempered Structures	Quench from 1400-1650 F (depending on composition), temper at 800-1300 F		
FABRICATING PROPERTIES			
Machinability	Depends on structure but has excellent machinability in both as-cast and annealed conditions		
Weldability	Can be welded by most fusion welding processes. For maximum ductility, welding should be done on fully annealed material. Composition affects weld quality. A 60 Ni-40% Fe filler wire is best for metal arc welding. Can be brazed with the lower melting BAg filler metals		
CORROSION RESISTANCE	Approx same corrosion resistance as gray irons of similar composition		
USES	Anvils for forging hammers; impellers, levers, cams, crankshafts, dies, jet engine burner support rings	Valve and pump bodies, pipe fittings, clamps, gear housings, tractor and farm machine parts	Track shoes, brake drums, gears, camshafts, pistons

[a]Obtained by heat treatment involving normalizing or quenching and tempering.
[b]Iron containing 1% silicon.

Nodular or Ductile Irons—Cast

Type →	120-90-02[a]	Heat Resistant	Austenitic
COMPOSITION, %	T.C. 3.4–3.8, Si 2.0–2.75, Mn 0.3–0.6, P 0.08 max, Ni 0–2.5, Mo 0–1.0, Mg 0.02–0.07	T.C. 2.8–3.8, Si 2.5–6.0, Mn 0.2–0.6, P 0.08 max, Ni 0–1.5, Mg 0.02–0.07	T.C. 3.0, Si 2.0–3.2, Mn 0.8–1.5, P 0.02 max, Ni 18–22, Cr 0–2.5
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.257	0.25	0.268
Melting Temp Range, F	2050–2150	2050–2150	2250
Thermal Conductivity (212 F), Btu/hr/sq ft/°F/ft	—	—	—
Coef of Ther Exp (70–400 F), per °F	6.6×10^{-6}	—	10.4×10^{-6}
Electrical Resistivity (75 F), microhm-cm	—	—	102
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	$22–25 \times 10^6$	$22–25 \times 10^6$	18.5×10^6
Tensile Strength, 1000 psi	120–150	60–100	58–68
Yield Strength, 1000 psi	90–125	45–75	32–38
Elongation (in 2 in.), %	2–7	0–20	7–40[c]
Hardness (Brinell)	240–325	140–300	140–200
Impact Strength (Charpy), ft-lb			
Unnotched	25–40	5–115	—
Notched	—	—	10–28
Fatigue Strength	Endurance ratio follows pattern set with other ferrous materials. For soft ferritic materials, notched endurance ratio is 50–55%; with the stronger irons, ratio drops to 30–40% or lower		
Compressive Strength	Ratio of compressive strength to tensile strength is about 2 to 1		
Creep Strength (0.0001%/hr), psi[d]			
800 F	—	—	18,500
1000 F	—	—	13,000
1200 F	—	—	5,700
1400 F	—	—	2,000
THERMAL TREATMENT			
Ferritic Structure (ferritizing anneal)	Heat in 1600–1650 F range, cool to 1300 F, hold 1–3 hr, furnace cool to 1100 F, air cool		—
Pearlitic-Ferritic Structures	Heat to 1600–1650 F, cool rapidly, reheat at 1100–1300 F		—
Pearlitic Structures	Normalize by air cooling from 1600–1650 F		—
Tempered Structures	Quench from 1400–1650 F (depending on composition), temper at 800–1300 F		—
FABRICATING PROPERTIES			
Machinability	Depends on structure but is excellent in both as-cast and annealed conditions		
Weldability	Can be welded by most fusion welding processes. For maximum ductility, welding should be done on fully annealed material. Composition affects weld quality. A 60 Ni-40% Fe filler wire is best for metal arc welding. Can be brazed with the lower melting BAg filler metals		
CORROSION RESISTANCE	Approx same corrosion resistance as gray irons of similar composition; superior to ordinary gray irons		
USES	Machine guides, pinions, gears, cams, dies, track rollers	Grate boxes, sinter pots, lead pots, glass molds, furnace doors	Impellers, grids, paper mill machine parts, pumps, valves

[a]Obtained by heat treatment involving normalizing or quenching and tempering.
[c]25–40% with 0% chromium.
[d]For 0% chromium.

Malleable Irons

Type and Grade →	Standard		Pearlitic
	32510	35018	
COMPOSITION, %	C 2.3–2.7, Si 1.5–0.8, Mn 0.55 max, P 0.18 max, S 0.20 max	C 2.0–2.45, Si 1.4–0.85, Mn 0.55 max, P 0.18 max, S 0.20 max	Same as standard grades except that Mn can be higher
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.259–0.263	0.259–0.263	0.260–0.268
Thermal Conductivity, Btu/hr/sq ft/°F/ft			
80 F	29.5	29.5	[b]
700 F	23.0	23.0	[b]
Coef of Ther Exp (68–212 F), per °F	5.9×10^{-6}	5.9×10^{-6}	7.5×10^{-6}
Specific Heat (70–750 F), Btu/lb/°F	0.133	0.133	—
Electrical Resistivity (68 F), microhm-cm	27–34	27–34	38.19–41.17
Magnetic?	Yes	Yes	Yes
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	25×10^6	25×10^6	28×10^6
Tensile Strength, 1000 psi	50–52	53–60	65–120
Yield Strength, 1000 psi	32–35	35–40	45–100
Elongation (in 2 in.), %	10–18	18–25	2–16
Reduction of Area, %	18–23	18–23	—
Hardness (Brinell)	110–156	110–156	160–285
Impact Strength (Charpy), ft-lb[a]	16.5	16.5	12
Fatigue Strength			
Endurance Limit, 1000 psi	25	31	30–32
Endurance Ratio	0.50	0.57	0.40
Mod of Elast in Compression, psi	25×10^6	25×10^6	23×10^6
Compressive Yield Strength, 1000 psi			
1% Permanent Set	28	28	43
At Failure	90+	90+	197–290
Ultimate Shear Strength, 1000 psi	45–48	48–54	65–100
Yield Strength in Shear, 1000 psi	29–32	32–36	—
Mod of Rupture in Torsion, psi	58,000	58,000	—
Poisson's Ratio	0.17	0.17	—
Allowable Working Stress (775 F), psi	5600	5600	—
THERMAL TREATMENT			
Hardening Temp, F	1500[c]	1500[c]	1500
Tempering Temp, F	—	—	About 600
FABRICATING PROPERTIES			
Casting Temperature Range, F	2600–2800	2600–2850	2600–2850
Shrinkage Allowance (contraction minus expansion during anneal), in.	11/64–1/32	11/64–1/32	11/64–1/32
Machinability Index (AISI B1112 steel = 100)	120	120	80–90
Weldability	Not fusion welded. Can be soldered and brazed		
CORROSION RESISTANCE	Resistant to atmospheric corrosion in rural, industrial and marine atmospheres; fresh and salt waters		
USES	Gear cases, brake supports, journal boxes, pipe fittings, pole line hardware, ordnance parts, marine deck fittings, anchors, parts for domestic appliances and business machines		Rocker arms, camshafts, gears, sprockets, tractor parts, agricultural machinery parts

[a] V-notch 0.079 in. deep, 0.394-in. sq bar.
[b] Estimated to be somewhat higher than for standard grades.
[c] Must first be heated to 1700 F to dissolve massive carbides.

Ingot and Wrought Irons

Type →	Ingot Iron	Wrought Iron	
COMPOSITION, %	C<0.02, Mn<0.02, Si trace, P 0.005, S 0.02	C 0.02, Mn 0.06, Si 0.13, P 0.13, S 0.01, slag 2.5	
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.28	0.278	
Melting Point, F	2794	2750	
Thermal Conductivity (212 F), Btu/hr/sq ft/°F/ft	38	34.5	
Coef of Ther Exp (68–212 F), per °F	6.8×10^{-6}	7.4×10^{-6}	
Specific Heat, Btu/lb/°F	0.11	0.11	
Electrical Resistivity (68 F), microhm-cm	9.7	11.97	
Magnetic?	Yes	Yes	
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	29.8×10^6	29.5×10^6	
		Longitudinal[a]	Transverse[a]
Tensile Strength, 1000 psi			
Annealed	42	—	—
Hot Rolled	44	48 (min)	39
Cold Drawn	73	—	—
Yield Point, 1000 psi			
Annealed	19	—	—
Hot Rolled	23	27 (min)	27
Cold Drawn	69	—	—
Elongation (in 2 in.), %			
Annealed	48	—	—
Hot Rolled	47	14[b]	2[b]
Cold Drawn	12	—	—
Reduction of Area, %			
Annealed	76	—	—
Hot Rolled	75	52	—
Cold Drawn	63	—	—
Hardness (Brinell)			
Annealed	69	—	—
Hot Rolled	83	97–105	97–105
Cold Drawn	142	—	—
Impact Strength (Charpy), ft-lb			
Annealed	19	—	—
Hot Rolled	—	24–28	—
Cold Drawn	—	—	—
Fatigue Strength (endurance limit), 1000 psi			
Annealed	26	—	—
Hot Rolled	28	23	19
Cold Drawn	33	—	—
FABRICATING PROPERTIES			
Annealing Temperature, F	1700–1800	1300–1400	
Forging Temperature Range, F	—	2100–2400	
Bending Temperature Range, F	—	1300–1400	
Machinability Index (AISI B1112 steel=100)	50	50	
Weldability	Readily joined by resistance, arc and gas methods		
CORROSION RESISTANCE	In spite of its purity, ingot iron has corrosion rates much the same as plain carbon steel	Current improved wrought iron has at least 25% greater corrosion resistance than former grade. Shows its greatest advantage over carbon steels in heat transfer equipment handling brines, industrial cooling waters and flue gases. Also used in steam condensate and drainage systems and other elevated temperature equipment	
AVAILABLE FORMS	Sheet and strip, wire, rail sections	Tubular products, plate, sheet, bars, structural shapes, wire, chain	
USES	Deep drawn parts, enameling stock, third rails, wire for electrical apparatus	Condensers and heat exchangers; piping for steam condensates, fresh and salt water, coolants, caustics; processing equipment; plates used for tanks, stacks, exhausts and breechings; bars for curing racks, manhole ladder steps, etc.	

[a] As rolled. [b] In 8 in.

Low and Medium Carbon Steels—Wrought

AISI Type →	C1010, C1015	C1018	C1020, C1025	C1030, C1035
COMPOSITION, %	C 0.08–0.18, Mn 0.30–0.60, P 0.040 max, S 0.050 max	C 0.15–0.20, Mn 0.60–0.90, P 0.040 max, S 0.050 max	C 0.18–0.28, Mn 0.30–0.60, P 0.040 max, S 0.050 max	C 0.28–0.38, Mn 0.60–0.90, P 0.040 max, S 0.050 max
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.283	0.283	0.283	0.283
Melting Temp Range, F	2750–2775	2750–2775	2750–2775	2700–2750
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27
Coef of Ther Exp (70–1200 F), per °F	8.4×10^{-6}	8.4×10^{-6}	8.4×10^{-6}	8.3×10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11
Elec Res (68 F), microhm-cm	14.3	14.3	14.3	19
Magnetic?	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES[a]				
Mod of Elast in Tension, psi	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$
Ten Str, 1000 psi				
Hot Rolled	51, 61	69	65, 67	80, 85
Cold Worked	56, 74	82	78, 80	85, 92
Yld Str, 1000 psi				
Hot Rolled	29, 46	48	43, 45	50, 54
Cold Worked	33, 62	70	66, 68	72, 79
Elong (in 2 in.), %				
Hot Rolled	38, 39	38	36, 36	30, 30
Cold Worked	35, 24	20	20, 20	26, 25
Red. of Area, %				
Hot Rolled	70, 61	62	59, 58	56, 53
Cold Worked	65, 57	57	55, 55	51, 50
Hardness (Brinell)				
Hot Rolled	101, 126	143	143, 143	163, 183
Cold Worked	113, 143	163	156, 163	179, 201
Impact Str	Markedly dependent on section size and processing details, such as deoxidation practice, rolling practice, etc.—more so than other mechanical properties			
Fatigue Str	Dependent on thermal and mechanical history, though not to the extent that impact strengths are. Conservative estimate of fatigue strength is 40–50% of tensile strength			
THERMAL TREATMENT[a]				
Annealing Temp, F	1650–1750	1650–1750	1650–1750, 1600–1700	1550–1700, 1500–1650
Hardening Temp, F	1650–1700[c]	1650–1700[c]	1600–1675[d]	1575–1650, 1525–1600[e]
Tempering Temp, F	300–1350	300–1350	300–1350	300–1350
FABRICATING PROPERTIES[a]				
Machinability Index[b]				
Hot Rolled	40, 50	52	50, 50	—, —
Cold Worked	45, 58	65	60, 60	67, 67
Weldability	Easily welded by all commercial welding procedures, including gas, arc, bronze, thermit, oxy-acetylene and submerged-melt processes. Preheat and postheat treatments sometimes necessary			
CORROSION RESISTANCE	Rusted by oxygen and water at room temperature, rate of attack increasing sharply as pH goes above 4 and decreasing below pH of 8. Dilute salt solutions increase corrosion rate. Attacked by acids, in general, but satisfactorily resistant to alkalis at normal temperatures. Corrosion rate in ordinary rusting not appreciably affected by carbon or alloy content or by cold working			
AVAILABLE FORMS	Can be obtained in all standard mill forms			
USES	Automobile spiders, gears, clutch disks, bolts, bearing races, camshafts, crankshafts, piston pins, cams, pneumatic tool cylinders, gun blocks, bushings, stud and collar bolts, shifter shoes, draw bars, pivot pins, cap screws, precision shafting, scythe blade heels, flanges, shackles, tie rods, drag links, steering gear connecting rods, thrust washers, wrenches			Brake shoe parts, gears, tie rods, clutch pedals, pitman arms, flywheel rings, crankshafts, camshafts, wheel hubs, tools, springs

[a] Where two values are given, they are for the two grades in that column.
[b] Based on AISI B1112 steel = 100.
[c] Quench in water, brine or caustic frequently used.
[d] Soluble oil solution used for hardening bolts; mineral oil used when quenching for machinability.
[e] Quenched in oil, water, or brine or caustic solutions.

Medium and High Carbon Steels—Wrought

AISI Type →	C1040, C1045	C1055, C1060	C1070, C1080	C1095
COMPOSITION, %	C 0.37–0.50, Mn 0.60–0.90, P 0.040 max, S 0.050 max	C 0.50–0.65, Mn 0.60–0.90, P 0.040 max, S 0.050 max	C 0.65–0.88, Mn 0.60–0.90, P 0.040 max, S 0.050 max	C 0.90–1.05, Mn 0.30–0.50, P 0.040 max, S 0.050 max
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.283	0.283	0.283	0.283
Melting Temp Range, F	2700–2750	—	—	—
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27
Coef of Ther Exp (70–1200 F), per °F	8.3×10^{-6}	8.1×10^{-6}	8.1×10^{-6}	8.1×10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11
Elec Res (68 F), microhm-cm	19	18	18	18
Magnetic?	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES[a]				
Mod of Elast in Tension, psi	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$
Ten Str, 1000 psi				
Annealed (1450 F)	100, 103[i]	97, 105	112, 119	100
Hot Rolled	91, 98	109, 116	128, 141	142
Hard. & Temp	113[c], 120[d]	150[e], 160[e]	174[f], 189[f]	180[g]
Yld Str, 1000 psi				
Annealed	88, 90[i]	52, 54	60, 66	53
Hot Rolled	58, 59	65, 70	77, 84	84
Hard. & Temp	86[c], 90[e]	105, 112	127, 142	118
Elong (in 2 in.), %				
Annealed	17, 14[i]	24, 20	17, 15	21
Hot Rolled	27, 24	19, 17	15, 12	9
Hard. & Temp	23[c], 18[e]	14, 12	13, 14	11
Red. of Area, %				
Annealed	42, 40[i]	47, 44	34, 22	42
Hot Rolled	50, 45	38, 36	27, 17	18
Hard. & Temp	62[c], 52[d]	45, 40	37, 34	30
Hardness (Brinell)				
Annealed	207, 217[i]	185, 192	207, 223	197
Hot Rolled	201, 212	235, 241	267, 293	293
Hard. & Temp	235[c], 277[d]	307, 321	354, 388	375
Impact Str (Izod), ft-lb				
Annealed	Markedly dependent on section size and processing details	22, 15	11, 6	5
Hot Rolled		18, 13	9, 5	3
Hard. & Temp		22, 15	13, 10	5
THERMAL TREATMENT[a]				
Normalizing Temp, F	—	1525–1650	1525–1650	1525–1650
Annealing Temp, F	1450–1600	1500–1575	1500–1575	1500–1575
Hardening Temp, F	1475–1575[h]	1450–1550	1450–1525	1430–1500
Tempering Temp, F	300–1350	400–1300	400–1300	400–1300
FABRICATING PROPERTIES[a]				
Hot Working Temp Range, F	—	1550–1650	1550–1650	1550–1650
Machinability Index (annealed)[b]	65, 60[i]	55, 53	45, 44	43
Weldability	Easily welded; preheat and postheat treatments necessary	High carbon content introduces difficulties in welding. Thermit process satisfactory; gas and arc methods difficult		
CORROSION RESISTANCE	Rust when brought into contact with moisture and air at room temperature; rates not appreciably affected by carbon content. If salts are present, corrosion rate increases. Attacked readily by acids; resistant to alkalis at ordinary temperatures			
AVAILABLE FORMS	All mill forms	Cold rolled strip, hot rolled strip, flat bars, forgings		
USES	Brake shoe parts, gears, tie rods, clutch pedals, crankshafts, camshafts	Heavy machine parts such as shafts, braces and control rods; hand tools such as wrenches, hammers, pliers, screwdrivers, hatchets and axes; agricultural machinery parts such as plowshares, disks for harrows and mower knives; and flat and helical springs		

[a] Where two values are given, they correspond to the two alloys listed in that column.
[b] Based on AISI B1112 steel = 100.
[c] 1-in. round, water quenched 1525 F, drawn at 1000 F.
[d] 1-in. round, water quenched 1550 F, tempered at 1000 F.
[e] 1-in. round, normalized 1650 F, reheated to 1550 F, oil quenched, tempered 700 F.
[f] 1-in. round, normalized 1650 F, reheated to 1525 F, oil quenched, tempered 700 F.
[g] 1-in. round, normalized 1650 F, reheated to 1475 F, oil quenched, tempered 700 F.
[h] Quenched in oil, water, or brine or caustic solutions.
[i] Cold worked.

Irons & Steels

Free-Cutting Steels—Wrought

AISI Type[a] →	B1111, C1211	B1112, C1212	B1113, C1213
COMPOSITION, %	C 0.13 max, Mn 0.60–0.90, P 0.07–0.12, S 0.08–0.15	C 0.13 max, Mn 0.70–1.00, P 0.07–0.12, S 0.16–0.23	C 0.13 max, Mn 0.70–1.00, P 0.07–0.12, S 0.24–0.33
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.283	0.283	0.283
Thermal Conductivity (212 F), Btu/hr/sq ft/°F/ft	27	27	27
Coef of Ther Exp (70–1200 F), per °F	8.4 x 10^{-6}	8.4 x 10^{-6}	8.4 x 10^{-6}
Specific Heat, Btu/lb/°F	0.10–0.11	0.10–0 11	0.10–0.11
Electrical Resistivity (68 F), microhm-cm	14.3	14.3	14.3
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	29 x 10^6	29 x 10^6	29 x 10^6
Tensile Strength, 1000 psi[c]			
9/16-In. Dia	85–110	85–110	85–110
1-In. Dia	80–105	80–105	80–105
2-In. Dia	70–90	70–90	70–90
Yield Strength, 1000 psi[c]			
9/16-In. Dia	75–100	75–100	75–100
1-In. Dia	70–90	70–90	70–90
2-In. Dia	60–85	60–85	60–85
Elongation (in 2 in.), %[c]			
9/16-In. Dia	10–20	10–20	10–20
1-In. Dia	12–22	12–22	12–22
2-In. Dia	10–20	10–20	10–20
Reduction of Area, %[c]			
9/16-In. Dia	30–50	30–50	30–50
1-In. Dia	35–55	35–55	35–55
2-In. Dia	30–50	30–50	30–50
Hardness (Brinell)[c]			
9/16-In. Dia	B90–102[b]	B90–102[b]	B90–102[b]
1-In. Dia	163–229	163–229	163–229
2-In. Dia	149–202	149–202	149–202
Impact Strength	Relatively low impact strength at low temperatures; should not be used for shock loading applications at subzero temperatures		
Fatigue Strength	Notch sensitive as cold drawn. Polished fatigue specimens will show expected values but poor finishing or processing of parts may cause low and erratic results for finished parts under dynamic or alternating stresses of relatively low intensity		
THERMAL TREATMENT			
Case Hardening	Case hardened for high surface hardness and good wear resistance where core properties not important Case hardness Rockwell C60–65		
Case Hardening Temp, F[d]	1450–1700	1450–1700	1450–1700
Tempering Temp, F	300	300	300
FABRICATING PROPERTIES			
Workability	Not recommended for operations involving cold metal movement, such as crimping, forming or bending		
Machinability Index[e]	90	100	125
Machining Speed (avg), sfm	153	170	213
AVAILABLE FORMS	Cold drawn shapes		
USES	Studs, nuts, fasteners, sleeves, collars, spacers, dowels, rods, handles, levers		

[a] B1111, B1112, B1113 are bessemer steels. C1211, C1212, C1213 are basic open hearth steels.
[b] Rockwell hardness.
[c] Cold drawn.
[d] Quench in water or oil
[e] Based on AISI B1112 Steel = 100.

Nitriding Steels—Wrought

Type →	135	135, Modified	N	EZ	5 Ni-2 Al
COMPOSITION, %	C 0.30–0.40, Mn 0.40–0.70, Si 0.20–0.40, Cr 0.90–1.40, Al 0.85–1.20, Mo 0.15–0.25	C 0.38–0.45, Mn 0.40–0.70, Si 0.20–0.40, Cr 1.40–1.80, Al 0.85–1.20, Mo 0.30–0.45	C 0.20–0.27, Mn 0.40–0.70, Si 0.20–0.40, Cr 1.00–1.50, Al 0.85–1.20, Mo 0.20–0.30, Ni 3.25–3.75	C 0.30–0.40, Mn 0.50–1.10, Si 0.20–0.40, Cr 1.00–1.50, Al 0.85–1.20, Mo 0.15–0.25, Se 0.15–0.25	C 0.20–0.25, Mn 0.25–0.45, Si 0.20–0.30, Ni 4.75–5.25, Cr 0.40–0.60, Mo 0.20–0.30, Al 1.80–2.20, V 0.08–0.15
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.283	0.283	0.283	0.283	—
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	30	30	30	30	—
Coef of Ther Exp (32–932 F), per °F	6.5×10^{-6}	6.5×10^{-6}	6.5×10^{-6}	6.5×10^{-6}	—
Spec Ht, Btu/lb/°F	0.11–0.12	0.11–0.12	0.11–0.12	0.11–0.12	—
Elec Res (68 F), microhm-cm	27–29	27–29	27–29	27–29	—
Magnetic?	Yes	Yes	Yes	Yes	—
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$
Ten Str (hard. & temp), 1000 psi	138[a], 121[b]	159[a], 145[b]	132[c], 190[d]	126[a]	206[e]
Yld Str (hard. & temp), 1000 psi	120[a], 103[b]	141[a], 125[b]	114[c], 180[d]	90[a, f]	202[e]
Elong (in 2 in., hard. & temp), %	20[a], 23[b]	18[a], 20[b]	22[c], 15[d]	17[a]	15[e]
Red. of Area (hard. & temp), %	58[a], 62[b]	56[a], 64[b]	59[c], 43[d]	44[a]	46.5[e]
Hardness (Brinell, hard. & temp)	280[a], 230[b]	320[a], 285[b]	277[c], 415[d]	255[a]	44[e, i]
	Cases produced by nitriding these steels will have hardnesses of about Rockwell 15N 94–95, excepting case on Nitralloy N which will be about Rockwell 15N 92–93				
Impact Str (Izod, hard. & temp), ft-lb	65[a], 80[b]	—	—	—	14[e, j]
Endurance Limit, 1000 psi	—	45[g1], 24[g2], 90[g3], 80[g4]	—	—	90[e, k]
THERMAL TREATMENT					
Annealing Temp, F	1650–1700	1650–1700	1500–1550[h]	1650–1700	—
Normalizing Temp, F	—	—	—	—	1700
Quenching Temp, F	1700–1750	1700–1750	1625–1675	1700–1750	1650
Tempering Temp, F	1100–1300	1100–1300	1100–1300	1100–1300	—
Solution Treating Temp, F	—	—	—	—	1275
Aging (8 hr min) Temp, F	—	—	—	—	1050
Nitriding Temp, F	930–1050 for periods ranging to 100 hr; 24 to 48-hr treatments are most widely used				
FABRICATING PROPERTIES					
Hot Working Temp Range, F	1950–2200	1950–2200	1950–2200	1950–2200	1950–2200
Weldability	Can be welded by atomic hydrogen process using Nitralloy welding rod; also flash welding				Can be welded with AWS ER310 stainless welding rod
CORROSION RESISTANCE	Provided the outer skin or white layer is not removed, the nitrided case is resistant to alkalis, crude oil, natural gas combustion products, tap water and unagitated salt water. Case is attacked by mineral acids. Removal of white layer greatly reduces resistance to attack				
USES	Most uses based on resistance to wear. Cylinder liners and barrels in aircraft engines, bushings, shafts, piston pins, spindles and thread guides, cams and camshafts, rubber and paper mill rolls. 5 Ni-2 Al recommended where highest core strength is required for heavily loaded wear resistant parts such as gears, bearings, shafts				

[a] Core properties; oil quenched from 1700 F, tempered at 1200 F.
[b] Core properties; oil quenched from 1700 F, tempered at 1300 F.
[c] Core properties; oil quenched from 1650 F, tempered at 1200 F before nitriding.
[d] Core properties; oil quenched from 1650 F, tempered at 1200 F after nitriding.
[e] Core properties; solution treated at 1275 F, aged 8 hr min at 1050 F.
[f] Proportional limit.
[g] Heat treated to 269 Bhn and tested (g1) unnitrided, unnotched; (g2) unnitrided with V notch; (g3) nitrided, unnotched; (g4) nitrided with V notch.
[h] Must be cooled rapidly below 1150 F to avoid precipitation hardening.
[i] Rockwell C. [j] Charpy V notch. [k] Polished.

Low Alloy Steels and H Steels—Wrought

COMPOSITION *

AISI Type ↓	C	Mn	Ni	Cr	Mo
13XX					
1330	0.28–0.33, 0.27–0.33	1.00–1.90, 1.45–2.05	—, —	—, —	—, —
1335	0.33–0.38, 0.32–0.38	1.60–1.90, 1.45–2.05	—, —	—, —	—, —
1340	0.38–0.43, 0.37–0.44	1.60–1.90, 1.45–2.05	—, —	—, —	—, —
1345	0.43–0.48, —	1.60–1.90, —	—, —	—, —	—, —
23XX, 25XX					
2317	0.15–0.20, —	0.40–0.60, —	3.25–3.75, —	—, —	—, —
2515	0.12–0.17, 0.12–0.18	0.40–0.60, 0.30–0.70	4.75–5.25, 4.70–5.30	—, —	—, —
2517	—, 0.14–0.20	—, 0.30–0.70	—, 4.70–5.30	—, —	—, —
E2517	0.15–0.20, —	0.45–0.60, —	4.75–5.25, —	—, —	—, —
31XX, 33XX					
3120	0.17–0.22, 0.17–0.23	0.60–0.80, 0.50–0.90	1.10–1.40, 1.00–1.45	0.55–0.75, 0.45–0.85	—, —
3130	0.28–0.33, 0.27–0.33	0.60–0.80, 0.50–0.90	1.10–1.40, 1.00–1.45	0.55–0.75, 0.45–0.85	—, —
3135	0.33–0.38, 0.32–0.38	0.60–0.80, 0.50–0.90	1.10–1.40, 1.00–1.45	0.55–0.75, 0.45–0.85	—, —
3140	0.38–0.43, 0.37–0.44	0.70–0.90, 0.60–1.00	1.10–1.40, 1.00–1.45	0.55–0.75, 0.45–0.85	—, —
3310	—, 0.07–0.13	—, 0.30–0.70	—, 3.20–3.80	—, 1.30–1.80	—, —
E3310	0.08–0.13, —	0.45–0.60, —	3.25–3.75, —	1.40–1.75, —	—, —
3316	—, 0.13–0.19	—, 0.30–0.70	—, 3.20–3.80	—, 1.30–1.80	—, —
E3316	0.14–0.19, —	0.45–0.60, —	3.25–3.75, —	1.40–1.75, —	—, —
40XX					
4023	0.20–0.25, —	0.70–0.90, —	—, —	—, —	0.20–0.30, —
4024	0.20–0.25, —	0.70–0.90, —	—, —	—, —	0.20–0.30, —
4027	0.25–0.30, —	0.70–0.90, —	—, —	—, —	0.20–0.30, —
4028	0.25–0.30, —	0.70–0.90, —	—, —	—, —	0.20–0.30, —
4032	0.30–0.35, 0.29–0.35	0.70–0.90, 0.60–1.00	—, —	—, —	0.20–0.30, 0.20–0.30
4037	0.35–0.40, 0.34–0.41	0.70–0.90, 0.60–1.00	—, —	—, —	0.20–0.30, 0.20–0.30
4042	0.40–0.45, 0.39–0.46	0.70–0.90, 0.60–1.00	—, —	—, —	0.20–0.30, 0.20–0.30
4047	0.45–0.50, 0.44–0.51	0.70–0.90, 0.60–1.00	—, —	—, —	0.20–0.30, 0.20–0.30
4053	0.50–0.56, 0.49–0.56	0.75–1.00, 0.65–1.10	—, —	—, —	0.20–0.30, 0.20–0.30
4063	0.60–0.67, 0.59–0.69	0.75–1.00, 0.65–1.10	—, —	—, —	0.20–0.30, 0.20–0.30
4068	0.63–0.70, 0.62–0.72	0.75–1.00, 0.65–1.10	—, —	—, —	0.20–0.30, 0.20–0.30
41XX					
4118	0.18–0.23, 0.17–0.23	0.70–0.90, 0.60–1.00	—, —	0.40–0.60, 0.30–0.70	0.08–0.15, 0.08–0.15
4130	0.28–0.33, 0.27–0.33	0.40–0.60, 0.30–0.70	—, —	0.80–1.10, 0.75–1.20	0.15–0.25, 0.15–0.25
4135	0.33–0.38, 0.32–0.38	0.70–0.90, 0.60–1.00	—, —	0.80–1.10, 0.75–1.20	0.15–0.25, 0.15–0.25
4137	0.35–0.40, 0.34–0.41	0.70–0.90, 0.60–1.00	—, —	0.80–1.10, 0.75–1.20	0.15–0.25, 0.15–0.25
4140	0.38–0.43, 0.37–0.44	0.75–1.00, 0.65–1.10	—, —	0.80–1.10, 0.75–1.20	0.15–0.25, 0.15–0.25
4142	0.40–0.45, 0.39–0.46	0.75–1.00, 0.65–1.10	—, —	0.80–1.10, 0.75–1.20	0.15–0.25, 0.15–0.25
4145	0.43–0.48, 0.42–0.49	0.75–1.00, 0.65–1.10	—, —	0.80–1.10, 0.75–1.20	0.15–0.25, 0.15–0.25
4147	0.45–0.50, 0.44–0.51	0.75–1.00, 0.65–1.10	—, —	0.80–1.10, 0.75–1.20	0.15–0.25, 0.15–0.25
4150	0.48–0.53, 0.47–0.54	0.75–1.00, 0.65–1.10	—, —	0.80–1.10, 0.75–1.20	0.15–0.25, 0.15–0.25
43XX, 46XX					
4320	0.17–0.22, 0.17–0.23	0.45–0.65, 0.40–0.70	1.65–2.00, 1.55–2.00	0.40–0.60, 0.35–0.65	0.20–0.30, 0.20–0.30
4337	0.35–0.40, 0.34–0.41	0.60–0.80, 0.55–0.90	1.65–2.00, 1.55–2.00	0.70–0.90, 0.65–0.95	0.20–0.30, 0.20–0.30
E4337	0.35–0.40, —	0.65–0.85, —	1.65–2.00, —	0.70–0.90, —	0.20–0.30, —
4340	0.38–0.43, 0.37–0.44	0.60–0.80, 0.55–0.90	1.65–2.00, 1.55–2.00	0.70–0.90, 0.65–0.95	0.20–0.30, 0.20–0.30
E4340	0.38–0.43, 0.37–0.44	0.65–0.85, 0.60–0.95	1.65–2.00, 1.55–2.00	0.70–0.90, 0.65–0.95	0.20–0.30, 0.20–0.30
4608	0.06–0.11, —	0.25–0.45, —	1.40–1.75, —	—, —	0.15–0.25, —
4615	0.13–0.18, —	0.45–0.65, —	1.65–2.00, —	—, —	0.20–0.30, —
4617	0.15–0.20, —	0.45–0.65, —	1.65–2.00, —	—, —	0.20–0.30, —
4620	0.17–0.22, 0.17–0.23	0.45–0.65, 0.35–0.75	1.65–2.00, 1.55–2.00	—, —	0.20–0.30, 0.20–0.30
4621	0.18–0.23, 0.17–0.23	0.70–0.90, 0.60–1.00	1.65–2.00, 1.55–2.00	—, —	0.20–0.30, 0.20–0.30
4640	0.38–0.43, 0.37–0.44	0.60–0.80, 0.50–0.90	1.65–2.00, 1.55–2.00	—, —	0.20–0.30, 0.20–0.30
47XX, 48XX					
4720	0.17–0.22, 0.17–0.23	0.50–0.70, 0.45–0.75	0.90–1.20, 0.85–1.25	0.35–0.55, 0.30–0.60	0.15–0.25, 0.15–0.25
4812	0.10–0.15, 0.09–0.15	0.40–0.60, 0.30–0.70	3.25–3.75, 3.20–3.80	—, —	0.20–0.30, 0.20–0.30
4815	0.13–0.18, 0.12–0.18	0.40–0.60, 0.30–0.70	3.25–3.75, 3.20–3.80	—, —	0.20–0.30, 0.20–0.30
4817	0.15–0.20, 0.14–0.20	0.40–0.60, 0.30–0.70	3.25–3.75, 3.20–3.80	—, —	0.20–0.30, 0.20–0.30
4820	0.18–0.23, 0.17–0.23	0.50–0.70, 0.40–0.80	3.25–3.75, 3.20–3.80	—, —	0.20–0.30, 0.20–0.30

* Phosphorus and sulfur contents usually range between 0.025 and 0.040% for low alloy steels. Silicon content usually ranges between 0.20 and 0.35%. All steels except those prefixed by an "E" are open hearth; "E" steels are electric furnace. The two sets of ranges are for standard low alloy steels and H steels, respectively, and apply to bar, billets and blooms not exceeding 200 sq in. in cross-sectional area.

Low Alloy Steels and H Steels—Wrought

COMPOSITION [a] (continued)

AISI Type ↓	C	Mn	Ni	Cr	Mo
50XX, 51XX					
5015	0.12–0.17, —	0.30–0.50, —	—, —	0.30–0.50, —	—, —
5046	0.43–0.50, 0.43–0.50	0.75–1.00, 0.65–1.10	—, —	0.20–0.35, 0.13–0.43	—, —
5117	0.15–0.20, —	0.70–0.90, —	—, —	0.70–0.90, —	—, —
5120	0.17–0.22, 0.17–0.23	0.70–0.90, 0.60–1.00	—, —	0.70–0.90, 0.60–1.00	—, —
5130	0.28–0.33, 0.27–0.33	0.70–0.90, 0.60–1.00	—, —	0.80–1.10, 0.75–1.20	—, —
5132	0.30–0.35, 0.29–0.35	0.60–0.80, 0.50–0.90	—, —	0.75–1.00, 0.65–1.10	—, —
5135	0.33–0.38, 0.32–0.38	0.60–0.80, 0.50–0.90	—, —	0.80–1.05, 0.70–1.15	—, —
5140	0.38–0.43, 0.37–0.44	0.70–0.90, 0.60–1.00	—, —	0.70–0.90, 0.60–1.00	—, —
5145	0.43–0.48, 0.42–0.49	0.70–0.90, 0.60–1.00	—, —	0.70–0.90, 0.60–1.00	—, —
5147	0.45–0.52, 0.45–0.52	0.70–0.95, 0.60–1.05	—, —	0.85–1.15, 0.80–1.25	—, —
5150	0.48–0.53, 0.47–0.54	0.70–0.90, 0.60–1.00	—, —	0.70–0.90, 0.60–1.00	—, —
5152	0.48–0.55, 0.48–0.55	0.70–0.90, 0.60–1.00	—, —	0.90–1.20, 0.85–1.30	—, —
5155	0.50–0.60, —	0.70–0.90, —	—, —	0.70–0.90, —	—, —
5160	0.55–0.65, 0.55–0.65	0.75–1.00, 0.65–1.10	—, —	0.70–0.90, 0.60–1.00	—, —
E50100	0.95–1.10, —	0.25–0.45, —	—, —	0.40–0.60, —	—, —
E51100	0.95–1.10, —	0.25–0.45, —	—, —	0.90–1.15, —	—, —
E52100	0.95–1.10, —	0.25–0.45, —	—, —	1.30–1.60, —	—, —
61XX [b]					
6117	0.15–0.20, —	0.70–0.90, —	—, —	0.70–0.90, —	—, —
6120	0.17–0.22, 0.17–0.23	0.70–0.90, 0.60–1.00	—, —	0.70–0.90, 0.60–1.00	—, —
6145	0.43–0.48, 0.42–0.49	0.70–0.90, 0.60–1.00	—, —	0.80–1.10, 0.75–1.20	—, —
6150	0.48–0.53, 0.47–0.54	0.70–0.90, 0.60–1.00	—, —	0.80–1.10, 0.75–1.20	—, —
86XX					
8615	0.13–0.18, —	0.70–0.90, —	0.40–0.70, —	0.40–0.60, —	0.15–0.25, —
8617	0.15–0.20, 0.14–0.20	0.70–0.90, 0.60–0.95	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
8620	0.18–0.23, 0.17–0.23	0.70–0.90, 0.60–0.95	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
8622	0.20–0.25, 0.19–0.25	0.70–0.90, 0.60–0.95	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
8625	0.23–0.28, 0.22–0.28	0.70–0.90, 0.60–0.95	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
8627	0.25–0.30, 0.24–0.30	0.70–0.90, 0.60–0.95	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
8630	0.28–0.33, 0.27–0.33	0.70–0.90, 0.60–0.95	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
8635	0.33–0.38, 0.32–0.38	0.75–1.00, 0.70–1.05	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
8637	0.35–0.40, 0.34–0.41	0.75–1.00, 0.70–1.05	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
8640	0.38–0.43, 0.37–0.44	0.75–1.00, 0.70–1.05	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
8641 [c]	0.38–0.43, 0.37–0.44	0.75–1.00, 0.70–1.05	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
8642	0.40–0.45, 0.39–0.46	0.75–1.00, 0.70–1.05	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
8645	0.43–0.48, 0.42–0.49	0.75–1.00, 0.70–1.05	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
8650	0.48–0.53, 0.47–0.54	0.75–1.00, 0.70–1.05	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
8653	0.50–0.56, 0.49–0.56	0.75–1.00, 0.70–1.05	0.40–0.70, 0.35–0.75	0.50–0.80, 0.50–0.85	0.15–0.25, 0.15–0.25
8655	0.50–0.60, 0.50–0.60	0.75–1.00, 0.70–1.05	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
8660	0.55–0.65, 0.55–0.65	0.75–1.00, 0.70–1.05	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.15–0.25, 0.15–0.25
87XX, 92XX					
8715	0.13–0.18, —	0.70–0.90, —	0.40–0.70, —	0.40–0.60, —	0.20–0.30, —
8717	0.15–0.20, —	0.70–0.90, —	0.40–0.70, —	0.40–0.60, —	0.20–0.30, —
8720	0.18–0.23, 0.17–0.23	0.70–0.90, 0.60–0.95	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.20–0.30, 0.20–0.30
8735	0.33–0.38, —	0.75–1.00, —	0.40–0.70, —	0.40–0.60, —	0.20–0.30, —
8740	0.38–0.43, 0.37–0.44	0.75–1.00, 0.70–1.05	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.20–0.30, 0.20–0.30
8742	0.40–0.45, 0.39–0.46	0.75–1.00, 0.70–1.05	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.20–0.30, 0.20–0.30
8750	0.48–0.53, 0.47–0.54	0.75–1.00, 0.70–1.05	0.40–0.70, 0.35–0.75	0.40–0.60, 0.35–0.65	0.20–0.30, 0.20–0.30
9255 [d]	0.50–0.60, —	0.70–0.95, —	—, —	—, —	—, —
9260 [d]	0.55–0.65, 0.55–0.65	0.70–1.00, 0.65–1.10	—, —	—, —	—, —
9261 [d]	0.55–0.65, 0.55–0.65	0.75–1.00, 0.65–1.10	—, —	0.10–0.25, 0.05–0.35	—, —
9262 [d]	0.55–0.65, 0.55–0.65	0.75–1.00, 0.65–1.10	—, —	0.25–0.40, 0.20–0.50	—, —
93XX, 98XX					
9310	—, 0.07–0.13	—, 0.40–0.70	—, 2.95–3.55	—, 1.00–1.45	—, 0.08–0.15
E9310	0.08–0.13, —	0.45–0.65, —	3.00–3.50, —	1.00–1.40, —	0.08–0.15, —
E9314	0.11–0.17, —	0.40–0.70, —	3.00–3.50, —	1.00–1.40, —	0.08–0.15, —
9840	0.38–0.43, 0.37–0.44	0.70–0.90, 0.60–0.95	0.85–1.15, 0.80–1.20	0.70–0.90, 0.65–0.95	0.20–0.30, 0.20–0.30
9845	0.43–0.48, —	0.70–0.90, —	0.85–1.15, —	0.70–0.90, —	0.20–0.30, —
9850	0.48–0.53, 0.47–0.54	0.70–0.90, 0.60–0.95	0.85–1.15, 0.80–1.20	0.70–0.90, 0.65–0.95	0.20–0.30, 0.20–0.30

[a] Phosphorus and sulfur contents usually range between 0.025 and 0.040% for low alloy steels. Silicon content usually ranges between 0.20 and 0.35%. All steels except those prefixed by an "E" are open hearth; "E" steels are electric furnace. The two sets of ranges are for standard low alloy steels and H steels, respectively, and apply to bar, billets and blooms not exceeding 200 sq in. in cross-sectional area.

[b] These types contain the following amounts of vanadium: 6117 0.10 min, 6120 0.10 min, 6145 0.15 min and 6150 0.15% min.

[c] Sulfur content is 0.040–0.060%.

[d] Silicon content is 1.80–2.20%.

Low Alloy Steels—Wrought

TYPICAL PHYSICAL PROPERTIES [a]

AISI Type →	13XX	23XX	25XX	40XX	41XX	43XX
Melting Temperature, F	—	2600–2620	2610–2620	—	—	2740–2750
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	38.3[c]	34.5–38.5[c]	27	24.7[d]	21.7[c]
Coef of Ther Exp (0–1200 F), per °F	7.9 x 10^{-6}[b]	8.0 x 10^{-6}	7.8 x 10^{-6}	8.3 x 10^{-6}[b]	—	8.1 x 10^{-6}
Specific Heat (68–212 F), Btu/lb/°F	0.10–0.11	0.11–0.12	0.11–0.12	0.10–0.11	0.11	0.107
Electrical Resistivity (68 F), microhm-cm	17	28.4[c]	—	19	22.3	30[c]

[a] Density for all low alloy steels is approximately 0.28 lb per cu in. [b] 68–1200 F. [c] 120 F. [d] 68 F.

TYPICAL MECHANICAL PROPERTIES [a]

AISI Type ↓	Ten Str, 1000 psi	Yld Str (0.2% offset), 1000 psi	Elong (in 2 in.), %	Red. of Area, %	Hardness, Brinell	Impact Str (Izod), ft-lb
1330[b]	122	100	19	52	248	—
1335[c]	126	105	20	59	262	—
1340[c]	137	118	19	55	285	—
2317[c]	107	72	27	71	222	84
2515[c]	113	94	25	69	233	85
E2517[c]	120	100	22	66	244	80
4023[d]	120	85	20	53	255	—
4032[e]	210	182	11	49	415	—
4042[f]	235	210	10	42	461	—
4053[g]	250	223	12	40	495	—
4063[h]	269	231	8	15	534	—
4130[i]	200	170	16	49	375	25
4140[j]	200	170	15	48	385	16
4150[k]	230	215	10	40	444	12
4320[d]	180	154	15	50	360	32
4337[k]	210	140	14	50	435	18
4340[k]	220	200	12	48	445	16
4615[d]	100	75	18	52	—	42
4620[d]	130	95	21	65	—	68
4640[i]	185	160	14	52	390	25
4815[d]	150	125	18	58	325	44
4817[d]	—	—	15	52	355	36
4820[j]	—	—	13	47	380	28
5120[d]	143	114	13	45	302	6
5130[m]	189	175	13	51	380	—
5140[m]	190	170	13	43	375	16
5150[m]	224	208	10	40	444	—
6120[n]	125	94	21	56	—	28
6145[o]	176	169	16	52	429	20
6150[o]	187	179	13	42	444	13
8620[p]	122	98	21	63	245	76
8630[p]	162	142	14	54	325	42
8640[p]	208	183	13	43	420	18
8650[p]	214	194	12	41	423	—
8720[p]	122	98	21	63	245	76
8740[p]	208	183	13	43	420	18
8750[p]	214	194	12	41	423	—
9255[p]	232[q]	215	9	21	477	6
9261[p]	258[r]	226	10	30	514	12

[a] Properties are for materials hardened and tempered as follows: [b] water quenched from 1525 F, tempered at 1000 F; [c] oil quenched from 1525 F, tempered at 1000 F; [d] pseudo-carburized 8 hr at 1700 F, oil quenched, tempered 1 hr at 300 F; [e] water quenched from 1525 F, tempered at 600 F; [f] oil quenched from 1500 F, tempered at 600 F; [g] oil quenched from 1475 F, tempered at 600 F; [h] oil quenched from 1450 F, tempered at 600 F; [i] water quenched from 1550–1600 F, tempered at 800 F; [j] oil quenched from 1550 F, tempered at 800 F; [k] oil quenched from 1525 F, tempered at 800 F; [l] normalized at 1650 F, reheated to 1475 F, oil quenched, tempered at 800 F; [m] normalized at 1625 F, reheated to 1550 F, water quenched, tempered at 800 F; [n] carburized 10 hr at 1680 F, pot cooled, oil quenched from 1525 F, tempered at 300 F; [o] normalized at 1600 F, oil quenched from 1575 F, tempered at 1000 F; [p] oil quenched, tempered at 800 F; [q] normalized at 1650 F, reheated to 1625 F, quenched in agitated oil, tempered at 800 F; [r] normalized at 1600 F, reheated to 1575 F, quenched in agitated oil, tempered at 800 F.

TYPICAL PHYSICAL PROPERTIES [a] (continued)

AISI Type →	46XX	48XX	51XX	61XX	86, 87XX	92, 94XX
Melting Temperature, F	—	2750	2720–2760	—	2745–2755	—
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27[d]	26.0[f]	27–34[g]	27	21.7[c]	27
Coef of Ther Exp (0–1200 F), per °F	6.3 x 10^{-6}[c]	8.6 x 10^{-6}	7.4 x 10^{-6}[h]	8.1 x 10^{-6}[b]	8.2 x 10^{-6}	8.1 x 10^{-6}[b]
Specific Heat (68–212 F), Btu/lb/°F	0.10–0.11	—	0.10–0.11	0.10–0.11	0.107	0.10–0.12
Electrical Resistivity (68 F), microhm-cm	—	30	21	21	30[c]	19–20

[a] Density for all steels is approximately 0.28 lb per cu in. [b] 68–1200 F. [c] 120 F. [d] 68 F. [e] 0–200 F. [f] 75 F. [g] 32–212 F. [h] 100–518 F.

MACHINABILITY, WELDABILITY, AVAILABILITY, USES [a]

AISI Type ↓	Mach Index[b]	Weldability	Available Forms	Uses
1330	62	Mn increases crack sensitivity and care must be taken	Billets, bars, forgings	Automotive, farm implements: axles, shafts, bolts, studs, gears, tie rods
1335	62			
1340	59			
2317	55	Good by most commercial procedures	Bar, forgings	Carburized gears, cams
2515	40		Bar, forgings, tubing; also mill forms	Heavy duty carburized parts: aircraft gears, piston pins
E2517	—			
4023	73	Weldable by procedures used for carbon steels; preheating or postheating sometimes necessary	All standard mill forms	Automotive parts such as countershafts, differential gears, transmission gears and shafts, leaf and coil springs, bolts, axles, steering arms; also hand tools
4032	70			
4042	65			
4053	56			
4063	52			
4130	60	Weldable by all procedures; difficulty increases with carbon content	All standard mill forms	Arbors, gears, shafts, bushings, axles, aircraft fuselage, bolts, clutch parts, machine tool parts
4140	62			
4150	45			
4320	51	Readily weldable by oxyacetylene, inert arc and electrical resistance methods	Bar, forgings, tubing, billets; also mill forms	Heavy duty, high strength parts: gears, bearing races, aircraft tubing, shafts, heavy forgings, churn drills
4337	51			
4340	51			
4615	58–60	Weldable by all procedures	All standard mill forms	Arbors, ball bearings, gears, spindles, camshafts, leaf and coil springs, shovels
4620	58–60			
4815, 4817, 4820	45	Ordinarily not welded	Billets, bar, tubing, forgings, plate	Heavy duty gears, rock bits, pump parts, sucker rods, machine tools
5120	65	Weldable by oxyacetylene, inert arc and electrical resistance methods	Bar, rod, tubing, forgings, castings	Transmission gears, steering knuckles, side gears, shafts, axles, coil and flat springs
5130	67			
5140	60			
5150	55			
6120	46	Weldable by all commercial methods	All standard mill forms	Carburized gears, shafts, pistons; springs, axles, pins, connecting rods
6145	27			
6150	26			
8620, 8720	57	Weldable by oxyacetylene, inert arc and electrical resistance methods; preheating desirable for grades with more than 0.30% carbon	Usually supplied as bar, forgings, tubing or billet; sometimes in other mill forms	Medium and heavy duty carburized gears, cams, bearing races; also heavy duty bolts, aircraft tubing, hand tools, shafts, forgings
8630	61			
8640, 8740	55			
8650, 8750	45			
9255	38	Not normally recommended	Billets, bar, forgings	Coil and flat springs, axles, chisels, bolts
9261	36			

[a] In general, corrosion resistance of these steels ranges from about the same to slightly better than carbon steels.
[b] Based on AISI B1112 steel = 100.

H Steels—Wrought

END QUENCH HARDENABILITY BAND LIMITS [a]

AISI Type ↓	"J" Distance, in.															
	1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1
13XX																
1330 H[b]	56-47	53-40	50-31	45-26	42-23	39-21	37 max	35 max	34 max	33 max	32 max	31 max	31 max	31 max	30 max	30 max
1335 H[c]	57-49	55-44	52-34	48-29	44-26	41-24	39-22	37-21	35-20	34 max	33 max	32 max	31 max	31 max	30 max	30 max
1340 H[c]	60-52	58-49	56-40	54-33	51-29	48-27	44-25	41-24	39-23	38-23	37-22	36-22	35-21	35-21	34-20	34-20
25XX																
2515 H[d]	44-37	42-30	40-24	37-20	34 max	31 max	29 max	28 max	27 max	26 max	25 max	24 max	24 max	23 max	23 max	22 max
2517 H[d]	46-38	45-31	43-25	41-21	37 max	34 max	32 max	31 max	30 max	29 max	28 max	27 max	27 max	26 max	26 max	25 max
31XX																
3120 H[c]	47-39	42-30	35-23	30-20	28 max	27 max	26 max	25 max	24 max	23 max	23 max	22 max	22 max	21 max	21 max	21 max
3130 H[b]	55-47	52-42	49-34	45-30	41-28	38-25	35-24	34-22	33-21	32-20	32 max	31 max	31 max	31 max	30 max	30 max
3135 H[c]	57-50	55-47	53-41	50-35	48-33	44-30	39-28	37-26	36-25	35-23	34-22	34-20	34 max	34 max	33 max	33 max
3140 H[c]	60-52	59-49	57-45	56-41	54-36	52-33	50-31	48-30	46-29	44-28	43-28	42-27	41-27	40-26	40-26	39-25
33XX																
3310 H[d]	43-36	42-35	42-33	41-31	40-30	40-29	39-28	38-27	37-26	37-26	37-26	36-26	36-25	36-25	35-25	35-25
3316 H[d]	47-39	46-38	46-37	45-35	45-33	45-32	44-32	44-31	44-31	43-31	43-31	43-31	42-31	42-30	42-30	41-30
40XX																
4032 H[b]	54-45	46-29	34-23	29-21	26 max	25 max	24 max	23 max	23 max	22 max	22 max	21 max	21 max	20 max	—	—
4037 H[c]	57-49	51-35	38-26	32-22	29-20	27 max	26 max	25 max	25 max	25 max	25 max	24 max	24 max	24 max	23 max	23 max
4042 H[c]	60-52	55-40	45-29	36-26	33-24	31-23	30-23	29-22	28-22	28-21	28-20	27-20	27 max	27 max	26 max	26 max
4047 H[c]	62-55	58-42	52-32	43-28	38-27	35-26	33-25	32-25	31-24	30-24	30-23	30-23	30-22	29-22	29-21	29-21
4053 H[c]	65-59	62-53	59-38	55-32	47-30	42-29	38-28	36-28	34-27	33-27	33-27	32-26	32-26	32-26	31-25	31-25
4063 H[c]	60 min	65-56	64-39	61-35	57-33	51-32	46-31	43-31	41-30	40-30	39-29	38-29	38-28	37-28	37-27	36-27
4068 H[c]	60 min	59 min	64-45	62-36	58-34	52-33	47-32	44-32	42-31	41-31	40-30	39-30	38-29	38-29	38-28	37-28
41XX																
4118 H[c]	46-36	35-23	28 max	25 max	23 max	21 max	20 max	—	—	—	—	—	—	—	—	—
4130 H[b]	55-46	51-38	47-31	42-27	38-26	35-25	34-24	33-23	32-22	32-21	32-20	31 max	31 max	30 max	30 max	29 max
4135 H[c]	58-50	56-48	55-45	53-40	51-36	49-33	47-31	45-30	44-29	42-28	41-27	40-27	39-27	38-26	38-26	37-26
4137 H[c]	59-51	58-49	57-48	55-43	54-39	52-36	50-34	48-33	46-32	45-31	44-30	43-30	42-30	42-29	41-29	41-29
4140 H[c]	60-53	59-51	58-50	57-47	56-42	55-39	54-37	53-35	52-34	51-33	49-33	48-32	47-32	46-31	45-31	44-30
4142 H[c]	62-55	61-53	61-52	60-50	59-47	58-44	57-41	56-39	55-37	54-36	53-35	53-34	52-34	51-34	51-33	50-33
4145 H[c]	63-55	62-54	61-53	61-52	60-50	59-48	59-45	58-42	57-40	57-38	56-37	55-36	55-35	55-35	55-34	54-34
4147 H[c]	64-57	64-56	63-55	63-54	62-53	62-51	61-48	60-45	59-42	59-40	58-39	57-38	57-37	57-37	56-37	56-36
4150 H[c]	65-59	65-58	65-57	64-56	64-55	63-53	62-50	62-47	61-45	60-43	59-41	59-40	58-39	58-38	58-38	58-38
43XX																
4320 H[c]	47-38	43-32	38-27	34-23	31-21	29-20	27 max	26 max	25 max	25 max	24 max	24 max	24 max	24 max	24 max	24 max
4337 H[c]	59-52	59-52	58-51	58-51	57-50	57-49	57-47	57-46	56-44	56-42	55-41	55-40	55-39	54-39	54-39	53-39
4340 H[c]	60-53	60-53	60-53	60-52	60-52	59-51	58-49	58-48	58-47	57-46	57-45	57-44	57-43	56-42	56-41	56-40
E4340 H[c]	60-53	60-53	60-53	60-53	60-53	60-53	59-52	59-51	58-51	58-50	58-49	57-48	57-47	57-46	57-45	57-44
46XX																
4620 H[c]	45-35	39-24	31 max	27 max	25 max	23 max	22 max	21 max	21 max	20 max	—	—	—	—	—	—
4621 H[c]	47-38	44-30	37-25	32-22	28 max	26 max	25 max	24 max	24 max	23 max	23 max	22 max	22 max	22 max	21 max	21 max
4640 H[c]	60-52	58-50	56-44	53-37	49-32	44-29	41-27	39-27	38-26	37-26	36-26	35-25	35-25	34-25	34-24	33-24
47XX,48XX																
4720 H[c]	47-39	39-27	32-21	28 max	26 max	24 max	23 max	22 max	21 max	21 max	21 max	20 max	—	—	—	—
4812 H[d]	43-34	41-26	37-21	33 max	29 max	27 max	25 max	24 max	24 max	23 max	23 max	22 max	22 max	21 max	21 max	21 max
4815 H[d]	44-37	42-30	39-24	35-21	31 max	29 max	28 max	27 max	26 max	25 max	24 max	24 max	24 max	23 max	23 max	23 max
4817 H[d]	46-38	44-32	41-27	37-23	33-21	31-20	29 max	28 max	27 max	26 max	25 max	25 max	25 max	25 max	24 max	24 max
4820 H[d]	48-40	46-38	43-31	40-27	37-25	35-23	33-22	31-21	29-20	28-20	28 max	27 max	27 max	26 max	26 max	25 max

[a] Rockwell C hardness value and distance from quenched end of standard end quench hardenability band. Range indicates maximum and minimum values. Steels heat treated as follows: [b] normalized at 1650 F, austenitized at 1600 F; [c] normalized at 1600 F, austenitized at 1550 F; [d] normalized at 1700 F, austenitized at 1550 F; [e] normalized at 1700 F, austenitized at 1700 F.

END QUENCH HARDENABILITY BAND LIMITS [a] (continued)

AISI Type ↓	"J" Distance, in.															
	1/16	1/8	3/16	1/4	5/16	3/8	7/16	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2
50XX,51XX																
5046 H[c]	62–55	56–32	46–27	35–25	33–24	32–23	31–22	30–21	29–20	28 max	27 max	26 max	25 max	24 max	23 max	23 max
5120 H[c]	46–34	36–23	30 max	27 max	24 max	22 max	21 max	—	—	—	—	—	—	—	—	—
5130 H[b]	55–46	51–39	47–32	42–28	38–25	36–22	34–20	33 max	32 max	31 max	30 max	29 max	27 max	26 max	25 max	24 max
5132 H[b]	56–47	52–40	48–32	42–27	38–24	36–22	34–20	33 max	32 max	31 max	30 max	29 max	28 max	27 max	26 max	25 max
5135 H[c]	57–49	55–43	52–35	47–30	43–27	40–24	38–22	37–21	36–20	35 max	34 max	33 max	32 max	32 max	31 max	30 max
5140 H[c]	59–52	57–48	54–38	50–33	46–30	43–28	40–27	38–25	37–24	36–23	35–21	34–20	34 max	33 max	33 max	32 max
5145 H[c]	62–55	60–51	58–42	56–35	53–32	50–30	47–29	44–28	42–26	41–25	39–24	38–23	37–22	37–21	36 max	35 max
5147 H[c]	64–56	62–54	61–52	60–45	59–37	58–34	57–32	56–31	55–30	54–29	53–27	52–26	51–25	50–24	49–22	48–21
5150 H[c]	65–58	63–56	61–49	59–38	56–34	53–32	50–31	47–30	45–29	43–28	42–27	41–26	40–25	39–24	39–23	38–22
5152 H[c]	65–58	64–57	63–55	62–51	60–45	59–39	58–37	57–35	56–34	55–32	53–31	51–30	50–29	48–27	47–26	45–25
5160 H[c]	60 min	65–59	64–56	63–47	61–39	59–36	56–35	52–34	48–33	47–32	46–31	45–30	44–29	43–28	43–28	42–27
61XX																
6120 H[c]	47–38	42–29	36–24	33–22	31–21	31–20	30 max	29 max	28 max	28 max	27 max	26 max	25 max	25 max	24 max	23 max
6145 H[b]	63–55	62–54	61–49	59–42	57–38	55–36	52–35	50–33	49–32	48–31	47–30	46–29	45–27	44–26	43–25	42–24
6150 H[b]	65–58	64–56	63–53	61–47	60–41	58–38	55–36	52–35	50–34	48–32	47–31	46–30	45–29	44–27	43–26	42–25
86XX																
8617 H[c]	44–33	38–24	31 max	27 max	25 max	23 max	22 max	21 max	21 max	20 max	—	—	—	—	—	—
8620 H[c]	47–37	41–27	34–21	30 max	28 max	26 max	25 max	24 max	23 max	23 max	23 max	23 max	23 max	22 max	22 max	22 max
8622 H[c]	49–39	44–30	37–24	32–20	30 max	28 max	26 max	25 max	25 max	24 max	24 max	24 max	24 max	24 max	24 max	24 max
8625 H[b]	51–41	46–32	40–27	35–23	32–21	30 max	28 max	27 max	27 max	26 max	26 max	26 max	26 max	25 max	25 max	25 max
8627 H[b]	52–43	48–35	43–29	38–26	34–24	32–22	30–21	29–20	28 max	28 max	28 max	27 max	27 max	27 max	27 max	27 max
8630 H[b]	55–46	52–39	47–32	41–28	37–26	34–24	33–22	31–21	30–21	30–20	29–20	29 max	29 max	29 max	29 max	29 max
8635 H[c]	57–49	55–45	53–39	50–33	46–30	43–28	40–26	37–25	36–24	35–23	34–23	33–23	33–23	33–22	32–22	32–22
8637 H[c]	58–51	57–48	55–42	53–36	49–32	46–30	43–28	40–26	39–25	37–25	36–24	36–24	35–24	35–24	35–23	35–23
8640 H, 8641 H[c]	60–53	59–51	58–46	55–39	52–34	49–31	45–29	42–28	41–26	39–26	38–25	38–25	37–24	37–24	37–24	37–24
8642 H[c]	62–54	61–52	60–48	58–42	55–37	52–33	49–31	46–29	44–28	42–28	41–27	40–27	40–26	39–26	39–26	39–26
8645 H[c]	63–56	63–54	61–50	60–45	58–39	55–35	52–33	49–31	47–30	45–29	43–28	42–28	42–27	41–27	41–27	41–27
8650 H[c]	65–58	64–57	63–54	62–50	60–44	59–39	58–36	56–34	55–33	53–32	52–31	50–31	49–30	47–30	46–29	45–29
8653 H[c]	65–59	65–58	64–57	64–56	63–53	62–47	62–44	61–42	61–40	60–39	59–38	59–37	59–36	59–35	58–35	58–34
8655 H[c]	59 min	58 min	56 min	54 min	65–49	64–43	63–40	62–38	61–37	60–35	59–34	58–34	57–33	56–33	55–32	53–32
8660 H[c]	60 min	60 min	59 min	57 min	53 min	47 min	44 min	65–42	64–40	64–39	63–38	62–37	62–36	61–36	60–35	60–35
87XX																
8720 H[c]	47–38	42–30	35–24	31–21	29 max	27 max	26 max	25 max	24 max	24 max	23 max	23 max	23 max	23 max	22 max	22 max
8740 H[c]	60–53	60–51	58–46	56–40	53–35	50–32	48–31	45–29	43–28	42–28	41–27	40–27	39–27	39–27	38–26	38–26
8742 H[c]	62–55	61–53	60–49	58–44	56–39	53–35	51–33	48–31	46–30	45–29	43–29	42–28	42–28	41–28	41–28	40–27
8750 H[c]	65–59	64–57	63–56	62–53	61–49	60–45	59–42	58–39	57–37	55–35	53–34	52–33	51–33	50–32	49–32	48–32
92XX																
9260 H[b]	60 min	64–53	62–41	58–36	52–35	47–34	43–33	40–32	38–31	37–31	36–30	36–30	35–29	35–29	35–28	34–28
9261 H[b]	60 min	65–59	64–52	63–42	60–37	54–36	45–35	42–34	39–33	38–32	37–31	37–31	36–30	36–30	35–29	35–29
9262 H[b]	60 min	60 min	65–56	64–48	62–39	59–37	55–36	48–35	45–34	43–33	41–33	39–32	38–31	37–31	36–30	36–30
93XX,98XX																
9310 H[d]	43–35	42–34	42–31	41–29	40–27	38–26	36–26	35–26	35–26	35–25	34–25	34–25	34–25	34–25	33–24	33–24
9840 H[c]	60–53	60–53	60–53	60–52	59–51	58–48	58–45	57–43	56–41	55–39	55–38	55–36	54–36	54–35	53–34	53–34
9850 H[c]	65–59	65–59	65–59	65–58	65–58	65–58	64–57	64–56	63–54	62–52	62–50	61–49	61–48	61–47	60–47	60–47

[a] Rockwell C hardness value and distance from quenched end of standard end quench hardenability band. Range indicates maximum and minimum values. Steels heat treated as follows: [b] normalized at 1650 F, austenitized at 1600 F; [c] normalized at 1600 F, austenitized at 1550 F; [d] normalized at 1700 F, austenitized at 1550 F; [e] normalized at 1700 F, austenitized at 1700 F.

Austenitic Stainless Steels—Wrought

AISI Type →	201	202
COMPOSITION, %	C 0.15 max, Mn 5.5–7.5, Cr 16.0–18.0, Ni 3.5–5.5, N 0.25 max	C 0.15 max, Mn 7.5–10.0, Cr 17.0–19.0, Ni 4.0–6.0, N 0.25 max
PHYSICAL PROPERTIES		
Density, lb/cu in.	0.28	0.28
Ther Cond (68–212 F), Btu/hr/sq ft/°F/ft	9.4	9.4
Coef of Ther Exp, per °F		
32 to 200 F	8.78 x 10^{-6}	—
32 to 600 F	9.7 x 10^{-6}	10.2 x 10^{-6}
32 to 900 F	10.1 x 10^{-6}	10.6 x 10^{-6}
32 to 1400 F	—	11.3 x 10^{-6}
Specific Heat, Btu/lb/°F	0.12	0.12
Electrical Resistivity (68 F), microhm-cm	69	69
Magnetic?	No	No
Magnetic Permeability (max)	1.02	1.02
MECHANICAL PROPERTIES		
Mod of Elast in Tension, psi	28.6 x 10^6	28 x 10^6
Tensile Strength, 1000 psi		
Annealed[a]		
Tested at Rm Temp	115, 114, 95[b]	105, —
Tested at 1200 F	—, 50	—
Tested at 1400 F	—, 37	—
Cold Worked[c]		
Quarter Hard	125	—
Half Hard	150	—
Yield Strength, 1000 psi		
Annealed[a]		
Tested at Rm Temp	55, 53, 47[b]	55, —
Tested at 1200 F	—, 21	—
Tested at 1400 F	—, 19	—
Cold Worked[c]		
Quarter Hard	75	—
Half Hard	110	—
Elongation (in 2 in.), %		
Annealed[a]		
Tested at Rm Temp	55, 57, 60[b]	55, —
Tested at 1200 F	—, 36	—
Tested at 1400 F	—, 38	—
Cold Worked[c]		
Quarter Hard	25	—
Half Hard	15	—
Hardness (Rockwell, annealed)	B90	B90
Rupture Stress (annealed, 1000 hr), 1000 psi		
Tested at 1200 F	22.0	—
Tested at 1400 F	7.0	—
THERMAL TREATMENT		
Annealing Temp, F	1850–2050	1850–2050
FABRICATING PROPERTIES		
Hot Working Temp Range, F	2100–2250	2100–2250
Formability	Moderate; similar to type 301	Good; similar to type 302
Machinability	Good	Good
Weldability	Similar to type 301; normally spot welded	Similar to type 302
CORROSION RESISTANCE	Good; similar to type 301	Good; similar to types 302, 304
AVAILABLE FORMS	Sheet, strip, some bar	Rod, bar, sheet, strip, plate
USES	Alternate for type 301, but tests should be made if severe corrosion conditions exist	Alternate for type 302, but tests should be made if severe corrosion conditions exist

[a] Where two values are given, they represent sheet and bar respectively. [b] Welded and annealed.
[c] Minimum value for sheet tested at room temperature.

Austenitic Stainless Steels—Wrought

AISI Type →	301	302	303	304, 304L
COMPOSITION, %	C 0.08–0.20, Mn 2 max, Si 1 max, P 0.04 max, S 0.03 max, Cr 16–18, Ni 6–8	C 0.08–0.20, Mn 2 max, Si 1 max, P 0.04 max, S 0.03 max, Cr 17–19, Ni 8–10	C 0.15 max, Mn 2 max, P, S or Se 0.07 min, Si 1 max, Cr 17–19, Ni 8–10, Mo or Zr 0.60 max	C 0.08 max (304) or 0.03 max (304L), Mn 2 max, Si 1 max, P 0.04 max, S 0.030 max, Cr 18–20, Ni 8–11
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.29	0.29	0.29	0.29
Melting Point Range, F	2550–2590	2550–2590	2550–2590	2550–2650
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	9.4	9.4	9.4	9.4
Coef of Ther Exp (32–212 F), per °F	9.5 x 10⁻⁶[a]	9.9 x 10⁻⁶	9.9 x 10⁻⁶	9.9 x 10⁻⁶
Spec Ht (32–212 F), Btu/lb/°F	0.12	0.12	0.12	0.12
Elec Res (68 F), microhm-cm	72	72	72	72
MECHANICAL PROPERTIES[b]				
Mod of Elast in Tension, psi	28.0 x 10⁶	28.0 x 10⁶	28.0 x 10⁶	28.0 x 10⁶
Ten Str, 1000 psi				
Annealed	110, 105, —	90, 90, 85	—, —, 90	85, 85, 85
Cold Worked[d]	185, —, —	—, —, 110[c]	—, —, 110[c]	—, —, 110[c]
Yld Str, 1000 psi				
Annealed	40, 40, —	40, 35, 35	—, —, 35	35, 30, 35
Cold Worked[d]	140, —, —	—, —, 75[c]	—, —, 75[c]	—, —, 75[c]
Elong (in 2 in.), %				
Annealed	60, 55, —	50, 60, 60	—, —, 50	50, 60, 60
Cold Worked[d]	8–9, —, —	—, —, 35[c]	—, —, 30[c]	—, —, 60
Red. of Area, %				
Annealed	—, 70, —	—, 70, 70	—, —, 55	—, 70, 70
Cold Worked	—	—, —, 60[c]	—, —, 50[c]	—
Hardness[e]				
Annealed	R_B85, —, —	R_B85, R_B80, 150	—, —, 160	R_B80, 150, 150
Cold Worked	R_B41, —, —	—, —, 240[c]	—, —, 240[c]	—, —, 240[c]
Impact Str (Izod), ft-lb				
Annealed	—, 165, —	—, 110, 110	—, —, 80	—, 110, 110
Cold Worked	—	—	—	—, —, 90[c]
Endurance Limit, 1000 psi				
Annealed	35, 39, —	—, —, 34	—, —, 35	35, 35, 34
Cold Worked	80, —, —	—	—	—
Creep Str (1% ext in 1000 hr), psi				
1000 F	—	17,000	—	17,000
1300 F	—	4,000	—	4,000
1500 F	—	1,200	—	1,200
FABRICATING PROPERTIES				
Annealing Temp, F[f]	1850–2050	1900–2050	1850–2050	1900–2050
Forging Temp (start), F[g]	2200	2100	2100	2200
Machinability	—	Fair; tough	Good; about 65% of screw stock	Fair; tough
Weldability	Very good	Not recommended; may crack		Very good
CORROSION RESISTANCE	Very good atmosphere resistance; slightly less than type 302	Excellent atmosphere resistance; also resists food products, acids and other chemicals	Very good atmosphere resistance; some resistance sacrificed for better machinability	Excellent atmosphere resistance; slightly better than type 302
AVAILABLE FORMS	Sheet, strip, wire	Sheet, strip, plate, bar, wire	Bar, wire	Sheet, strip, plate, bar, wire
USES	Lightweight, high strength applications; transportation equipment, roof drainage and trim	General purpose	General purpose, but where better machinability (than type 302) is required	Light welded construction where corrosive conditions are not too severe

[a]For 32-600 F range. [b]Where three values are given, they represent sheet, plate and bar in that order.
[c]Cold drawn, high tensile 1½-in. dia bar. [d]Minimum value at full hard temper.
[e]Values are Brinell except where Rockwell scale is noted. [f]Cool rapidly after anneal.
[g]Finish forging all grades at 1700 F or above.

continued on next page

Austenitic Stainless Steels—Wrought

AISI Type →	309, 309S	310, 310S	316, 316L	321
COMPOSITION, %	C 0.20 max (309), C 0.08 max (309S), Mn 2 max, P 0.04 max, S 0.03 max, Si 1 max, Cr 22–24, Ni 12–15	C 0.25 max (310), C 0.08 max (310S), Mn 2 max, P 0.04 max, S 0.03 max, Si 1.5 max, Cr 24–26, Ni 19–22	C 0.10 max (316), C 0.03 max (316L), Mn 2 max, Si 1 max, P 0.04 max, S 0.03 max, Cr 16–18, Ni 10–14, Mo 2–3	C 0.08 max, Mn 2 max, Si 1 max, P 0.04 max S 0.03 max, Cr 17–19, Ni 8–11, Ti 5 x C
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.29	0.29	0.29	0.29
Melting Point Range, F	2550–2650	2550–2650	2500–2550	2550–2600
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	8	8	9.4	9.3
Coef of Ther Exp (32–600 F), per °F	9.3×10^{-6}	9.0×10^{-6}	9.0×10^{-6}	9.5×10^{-6}
Spec Heat (32–212 F), Btu/lb/°F	0.12	0.12	0.12	0.12
Elec Res (68 F), microhm-cm	78	78	74	72
MECHANICAL PROPERTIES[b]				
Mod of Elast in Tension, psi	29.0×10^6	2.9×10^6	28.0×10^6	28.0×10^6
Ten Str (ann.), 1000 psi	90, 95, 95	95, 95, 95	90, 85, 80	90, 85, 85
Yld Str (ann.), 1000 psi	45, 40, 40	45, 45, 45	40, 35, 30	35, 30, 35
Elong (in 2 in., ann.), %	45, 45, 45	45, 50, 50	50, 55, 60	50, 55, 55
Red. of Area (ann.), %	—, —, 65	—, —, —	—, —, 70	—, —, 65
Hardness (ann.)[c]	R_B85, 170, 160	R_B85, —, R_B89	R_B85, 150, 150	R_B80, 160, 150
Impact Str (Izod, ann.), ft-lb	—, —, 110	—, —, 85	—, —, 110	—, —, 110
Endurance Limit (ann.), 1000 psi	—	—, —, —	39, 39, 38	—, —, 38
Creep Str (1% ext in 10,000 hr), psi				
1000 F	15,900	17,000	25,000	18,000
1300 F	4,500	5,000	7,900	4,500
1500 F	1,000	1,000	2,800	850
FABRICATING PROPERTIES				
Annealing Temp, F	1900–2050	1900–2100	1850–2050	1900–2050
Forging Temp (start), F[e]	2150	2000–2250	2200	2250
Machinability	Fair; tough	Fair; tough	Fair; tough	Fair; tough
Weldability	Good	Good	Very good	Very good
CORROSION RESISTANCE	Excellent atmosphere resistance; better than type 302. Resists destructive heat scaling up to 2000 F	Excellent atmospheric resistance; better than type 309. Resists scaling to 2100 F	Best of any standard stainless steel. Greater resistance than type 302 to reducing acids, sea water and other corrosive media causing pitting type of corrosion. Intergranular corrosion due to welding eliminated in 316 ELC	Excellent atmosphere resistance; similar to type 302. Not subject to harmful carbide precipitation
AVAILABLE FORMS	Sheet, strip, plate, bar, wire	Sheet, strip, plate, bar	Sheet, strip, plate, bar, wire	Sheet, strip, plate, bar, wire
USES	Heat resisting applications	Heat exchangers, petroleum refining and chemical processing equipment, gas turbines	Processing equipment exposed to severe corrosive media. Stressed parts that operate at high temperatures	Welded equipment used in the unannealed condition and exposed to corrosive conditions. Equipment that must operate in the sensitization range (800-1650 F)

[b] Where three values are given, they represent sheet, plate and bar in that order.
[c] Values are Brinell except where Rockwell scale is noted.
[e] Finish forging in all grades at 1700 F or above.

Ferritic Stainless Steels—Wrought

AISI Type →	405	430	430F	446
COMPOSITION, %[a]	C 0.08, Mn 1.00, Si 1.00, P 0.04, S 0.03, Cr 11.5–14.5, Al 0.10–0.30	C 0.12, Mn 1.00, Si 1.00, P 0.04, S 0.03, Cr 14.0–18.0	C 0.12, Mn 1.25, P 0.06, S 0.15 min, Cr 14.0–18.0	C 0.20, Mn 1.50, Si 1.00, P 0.04, S 0.03, Cr 23.0–27.0, N 0.25
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.28	0.28	0.28	0.27
Melting Temp Range, F	2700–2790	2600–2750	2600–2750	2600–2750
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	—	15.1	15.1	12.1
Coef of Ther Exp (32–212 F), per °F	6.0×10^{-6}	5.8×10^{-6}	5.8×10^{-6}	5.8×10^{-6}
Spec Ht, Btu/lb/°F	0.11	0.11	0.11	0.12
Elec Res (70 F), microhm-cm	60.0	60.0	60.0	67.0
Magnetic?	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	29×10^6	29×10^6	29×10^6	29×10^6
Ten Str, 1000 psi				
Annealed	65–70	75	80	80–85
Cold Worked	85	75–90	80–90	85
Yld Str (0.2% offset), 1000 psi				
Annealed	35–40	40–45	55	50–55
Cold Worked	70	45–80	55–80	70
Elong (in 2 in.), %				
Annealed	25–30	25–30	25	20–25
Cold Worked	20	15–25	15–25	20
Red. of Area, %				
Annealed	50–60	60–65	60–65	45
Cold Worked	60	55–65	55–65	45
Hardness (Rockwell)				
Annealed	B75–90	B80	B80	B83–B86
Cold Worked	185[b]	B95	B95	B90
Impact Str (Izod, annealed), ft-lb	25[c]	—	—	2
Creep Str (1%, 1000 F), 1000 psi				
10,000 Hr	—	8.5	8.5	6.0
100,000 Hr	—	7.0	7.0	4.2
THERMAL TREATMENT				
Annealing Temp, F	1350–1500	1400–1500	1250–1400	1450–1600
FABRICATIN PROPERTIES				
Hot Working Temp Range, F	1950–2050	1900–2050	1950–2100	1950–2050
Machinability	Good	Fair	Excellent	Fair
Weldability	Excellent for fusion welding	Fair; welds are brittle	Not recommended	Fair; great care required because of high Cr content
CORROSION RESISTANCE	Good resistance to weather, water, some chemicals	Excellent resistance to weather, water; good resistance to most chemicals	Very good resistance to weather, water; some resistance sacrificed for better machinability	High resistance to corrosion and scaling; one of the most oxidation resistant steels commercially available
AVAILABLE FORMS	Bar, plate, sheet	Bar, plate, sheet, strip	Bar	Bar, plate, sheet, strip
USES	Lining for oil stills; weldments where 12% Cr gives sufficient corrosion resistance	General purpose grade; substitute for type 302; automobile and other trim, kitchen equipment, chemical equipment (430F is free-machining grade)		High temperature service up to 2150 F. Furnace parts, glass molds, pyrometer tubes, chemical processing equipment

[a] Maximum values unless otherwise stated. [b] Brinell. [c] Minimum.

Martensitic Stainless Steels—Wrought

AISI Type →	403, 410	414	416	420	431
COMPOSITION, %	C 0.15 max, Cr 11.5–13.5	C 0.15 max, Cr 11.5–13.0, Ni 1.25–2.5	C 0.15 max, Cr 12–14, P, S or Se 0.07 min, Mo or Zr 0.06 max	C > 0.15, Cr 12–14	C 0.20 max, Cr 15–17, Ni 1.25–2.50
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.28	0.28	0.28	0.28	0.28
Melting Point, F	2700–2790	—	2700–2790	2650–2750	2650
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	14.4	14.4	14.4	14.4	11.7
Coef of Ther Exp, per °F					
32–212 F	5.5×10^{-6}	5.8×10^{-6}	5.5×10^{-6}	5.7×10^{-6}	6.5×10^{-6}
32–1200 F	6.5×10^{-6}	—	6.5×10^{-6}	6.8×10^{-6}	—
Spec Ht (32–212 F), Btu/lb/°F	0.11	0.11	0.11	0.11	0.11
Elec Res (rm temp), microhm-cm	57	70	57	55	72
Magnetic?	Yes	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	29.0×10^6	29.0×10^6	29.0×10^6	29.0×10^6	29.0×10^6
Ten Str, 1000 psi					
Annealed	65–75	115–120	75	95	125
Hard. & Temp.	90–190	120–200	90–190	230	125–205
Yld Str, 1000 psi					
Annealed	35–50	90–105	40	50	95
Hard. & Temp.	60–145	105–150	60–145	195	90–155
Elong (in 2 in.), %					
Annealed	25–35	15–20	30	25	20
Hard. & Temp.	15–30	15–20	12–25	8	15–20
Hardness (Brinell)					
Annealed	155	235	155	195	260
Hard. & Temp.	180–390	250–410	180–390	500	260–415
Impact Str (Izod), ft-lb					
Annealed	90	50	70	—	—
Hard. & Temp.	35–75	45–50	20–60	10	30–50
Endurance Limit (annealed), 1000 psi	40	45	40	40	45
Creep Str (1% ext in 10,000 hr, annealed), psi					
1000 F	9200	—	9200	—	—
1300 F	1000	—	1000	—	—
THERMAL TREATMENT					
Annealing Temp, F	1500–1650	—	1500–1650	1550–1650	—
Hardening Temp, F	1700–1850	1800–1900	1700–1850	1800–1900	1800–1950
Tempering Temp, F	400–1400	400–1300	400–1400	300–700	400–1200
FABRICATING PROPERTIES					
Machinability	Fair	Poor	Good; 80% of screw stock	Fair	Poor
Weldability	Fair; small welds can be annealed	Poor	Poor	Fair	Poor
Forging Temp (start), F	2000–2200	2100–2200	2100–2300	2000–2200	2100–2250
CORROSION RESISTANCE	Good resistance to weather and water; also good resistance to some chemicals				
AVAILABLE FORMS	Plate, sheet, strip, bar, tube, rounds, structural and bar shapes, round and flat wire, tubing				
USES	Steam turbine blades, highly stressed parts	Springs, knife blades, tempered rules	Automatic screw machine parts	Cutlery, surgical instruments, ball bearings, magnets	High strength parts

Martensitic Stainless Steels—Wrought

AISI Type →	440A	440B	440C	501	502
COMPOSITION, %	C 0.60–0.75, Cr 16–18, Mo 0.75 max	C 0.75–0.95, Cr 16–18, Mo 0.75 max	C 0.95–1.20, Cr 16–18, Mo 0.75 max	C > 0.10, Cr 4–6	C 0.10 max, Cr 4–6
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.28	0.28	0.28	0.28	0.28
Melting Point, F	2500–2750	2500–2750	2500–2750	2700–2800	2700–2800
Ther Cond (212 F), Btu/hr/sq ft/°F/ft.	14.0	14.0	14.0	21.2	21.2
Coef of Ther Exp, per °F					
32–212 F	5.6×10^{-6}	5.6×10^{-6}	5.6×10^{-6}	6.2×10^{-6}	6.2×10^{-6}
32–1200 F	—	—	—	7.3×10^{-6}	7.3×10^{-6}
Spec Ht (32–212 F), Btu/lb/°F	0.11	0.11	0.11	0.11	0.11
Elec Res (rm temp), microhm-cm	60	60	60	40	40
Magnetic?	Yes	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	29.0×10^6	29.0×10^6	29.0×10^6	29.0×10^6	29.0×10^6
Ten Str, 1000 psi					
Annealed	105	107	110	70	65–70
Hard. & Temp.	260	280	285	115–175	—
Yld Str, 1000 psi					
Annealed	60	62	65	30	25–30
Hard. & Temp.	240	270	275	90–135	—
Elong (in 2 in.), %					
Anneafed	20	18	14	28	30
Hard. & Temp.	5	3	2	15–20	—
Hardness (Brinell)					
Annealed	215	220	230	160	150
Hard. & Temp.	510	555	580	240–370	—
Impact Str (Izod), ft-lb					
Annealed	2	2	2	—	85
Hard. & Temp.	4	3	2	—	—
Endurance Limit (annealed), 1000 psi	40	40	40	35	35
Creep Str (1% ext in 10,000 hr, annealed), psi					
1000 F	Not used in fatigue applications			9500	9500
1300 F				800	800
THERMAL TREATMENT					
Annealing Temp, F	1550–1650	1550–1650	1550–1650	1525–1600	1525–1600
Hardening Temp, F	1850–1950	1850–1950	1850–1950	1600–1700	—[a]
Tempering Temp, F	300–800	300–800	300–800	400–1400	—[a]
FABRICATING PROPERTIES					
Machinability	Fair	Fair	Fair	—	—
Weldability	Welding not generally recommended	Welding not generally recommended	Welding not recommended	—	—
Forging Temp (start), F	1900–2200	1900–2150	1900–2100	—	—
CORROSION RESISTANCE	Good resistance to weather and water; also good resistance to some chemicals				
AVAILABLE FORMS	Plate, sheet, strip, bar, tube, rounds, structural and bar shapes, round and flat wire, tubing				
USES	Instruments, cutlery, valves			Applications requiring heat resistance and good mechanical properties at elevated temperatures	

[a] Generally used in annealed condition only.

High Temperature Steels—Wrought

Type →	Martensitic Stainless			Low Alloy	
	422, 1420 WM	1415 NW (Greek Ascoloy)	1430 MV (Lapelloy)	Chromoloy (14 CMV)	17-22AS (14 MV)
COMPOSITION, %	C 0.20, Mn 0.65, Si 0.55, Cr 13.0, Ni 0.75, Mo 0.95, W 1.0, V 0.35, Fe bal	C 0.17, Mn 0.40, Si 0.30, Cr 12.75, Ni 1.95, Mo 0.15, W 3.0, Cu 0.13, Fe bal	C 0.30, Mn 1.05, Si 0.30, Cr 11.80, Ni 0.25, Mo 2.80, V 0.25, Fe bal	C 0.20, Mn 0.50, Si 0.75, Cr 1.0, Mo 1.0, V 0.10, Fe bal	C 0.30, Mn 0.55, Si 0.70, Cr 1.30, Mo 0.50, V 0.25, Fe bal
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.281	0.284	0.281	0.285	0.283
Melting Temp Range, F	2675–2700	2660–2670	2700–2750	—	2700–2750
Ther Cond (800 F), Btu/hr/sq ft/°F/ft	15.8	—	15.8	—	17.3
Coef of Ther Exp (70–1000 F), per °F	6.5×10^{-6}	6.3×10^{-6}	6.5×10^{-6}	7.9×10^{-6}	7.8×10^{-6}
MECHANICAL PROPERTIES[a]					
Mod of Elast in Tension, psi					
Room Temp	30×10^6	29×10^6	30×10^6	31.6×10^6	29.5×10^6
1000 F	21.5×10^6	21.5×10^6	22×10^6	25.4×10^6	20×10^6
Ten Str, 1000 psi					
Room Temp	235	170	157	139	150
800 F	221	135	123 (900 F)	119	121
1000 F	—	103	89 (1100 F)	103	91
Yld Str (0.2% offset), 1000 psi					
Room Temp	186	150	125	117	127
800 F	197	122	94 (900 F)	96	101
1000 F	—	98	81 (1100 F)	85	78
Elongation (in 2 in.), %					
Room Temp	10	13.3	12	8 (min)	16.5
800 F	13.5	13.3	10 (900 F)	—	18
1000 F	—	17.1	28 (1100 F)	—	18
Impact Str (Charpy), ft-lb					
Room Temp	19.5	19.5	10.0	—	31
1000 F	38.5	—	15.0	—	37
Fatigue Str (10^7 cycles), 1000 psi					
900 F	45[b]	—	53[d]	—	—
1100 F	32[b]	53 (1000 F)	36[d]	—	—
Rupture Str (1000 F), 1000 psi					
10 Hr	71	48[c]	73[e]	96	95
100 Hr	63	42[c]	65[e]	78	74
1000 Hr	57	36[c]	58[e]	52	55
10,000 Hr	49	31[c]	48[e]	32	31
FABRICATING PROPERTIES					
Hot Working Temp, F	1700–2100	1700–2200	1700–2200	1500–2100	1500–2100
Cold Workability	Fair	Fair	Fair	Good	Good
Machinability	Fair to good	Poor	Fair to good	Good	Good
Weldability	Not recommended	Not recommended	Not recommended	Excellent	Very good
CORROSION RESISTANCE	Resist atmospheric corrosion, weak organic acids and oxidizing acids (such as nitric); do not have the superior resistance to pitting by dilute reducing acids which characterizes the 300 series stainless steels. Good oxidation resistance up to 1450 F			Poor res compared to other alloys covered here; easily and severely pitted in salt spray test; can be protected with paints. Good oxidation resistance up to 1000 F	
AVAILABLE FORMS	Sheet, strip, plate, bar, forgings, tubing			Bar, forgings, plate, sheet, strip	Bar, forgings
USES	Turbine buckets, jet engine compressor blades, etc., requiring high strength at high temperatures				

[a] Properties for materials in the following conditions:
422, 1420 WM: austenitized at 1900 F, oil quenched, double tempered 2 hr at 1200 F and 2 hr at 800 F, air cooled.
1415 NW (Greek Ascoloy): austenitized ½ hr at 1800 F, oil quenched, tempered 2 hr at 1050 F, air cooled.
1430 MV (Lapelloy): austenitized at 2000 F, oil quenched, tempered 2 hr at 2000 F, air cooled.
Chromoloy: normalized 1 hr at 1650–1750 F, air cooled, tempered 2 hr at 1200 F, air cooled.
17–22 AS (14 MV): normalized from 1650–1750 F, tempered 6 hr at 1225 F, air cooled.
[b] Austenitized at 1900 F, tempered 4 hr at 1300 F.
[c] Austenitized ½ hr at 1800 F, air cooled, tempered 1½ hr at 1260 F.
[d] Hardened ¾ hr at 2000 F, salt quenched, held ¾ hr at 800 F, air cooled, tempered 4 hr at 1320 F, air cooled.
[e] Austenitized at 2000 F, oil quenched, tempered 2 hr at 1300 F.

Ultra High Strength Steels—Wrought

Type →	Unimach I, Vascojet	MX-2, UCX2	300-M	D-6A
COMPOSITION, %	C 0.40, Mn 0.35, Si 1.0, Cr 5.0, Mo 1.4, V 0.45, Fe bal	C 0.39, Mn 0.70, Si 1.0, Cr 1.10, Mo 0.25, V 0.15, Co 1.0, Fe bal	C 0.40, Mn 0.75, Si 1.60, Ni 1.85, Cr 0.85, Mo 0.40, V 0.08, Fe bal	C 0.46, Mn 0.75, Si 0.22, Ni 0.55, Cr 1.0, Mo 1.0, Fe bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.281	0.276	—	0.283
Ther Cond (1100 F), Btu/hr/sq ft/°F/ft	16.6	—	—	—
Coef of Ther Exp, per °F	7.4 x 10^{-6} [b]	5.68 x 10^{-6} [c]	7.61 x 10^{-6} [d]	—
MECHANICAL PROPERTIES [a]				
Mod of Elast in Tension, psi				
Room Temp	30 x 10^6	29.4 x 10^6	—	30 x 10^6
400 F	27.6 x 10^6	—	—	24.4 x 10^6
800 F	21.9 x 10^6	—	—	23.7 x 10^6
Ten Str, 1000 psi				
Room Temp	295	279	289	284
500 F	270	—	270	267
800 F	252	—	232 (700 F)	185 [e]
1000 F	220	—	—	139 [f]
Yld Str (0.2% offset), 1000 psi				
Room Temp	247	239	242	250
500 F	220	—	200	188
800 F	199	—	178 (700 F)	159 [e]
1000 F	172	—	—	121 [f]
Elongation (in 2 in.), %				
Room Temp	12.0	5.5	10.0	7.5
500 F	9.8	—	13.3	15.2
800 F	12.0	—	15.0	15.2 [e]
1000 F	15.0	—	—	19.8 [f]
Red. of Area, %				
Room Temp	39.9	—	38	26.8
500 F	33.0	—	35	55.0
800 F	35.2	—	52 (700 F)	55.0 [e]
1000 F	43.0	—	—	64.5 [f]
Impact Str (Charpy), ft-lb				
—200 F	15 (—100 F)	—	11	10
Room Temp	15	—	22	14
500 F	31	—	23	26
Fatigue Str (10^8 cycles), 1000 psi	135	—	116	110
Rupture Str (900 F), 1000 psi				
10 Hr	240	—	—	—
100 Hr	210	—	—	144
1000 Hr	140	—	—	97
FABRICATING PROPERTIES				
Hot Working Temp Range, F	1700–2100	1650–1950	1700–2250	1800–2250
Machinability	Readily machined in annealed condition			
Weldability	Readily fusion welded with shielded arc; preheat to 1000 F, postheat at 600 F	Excellent by tungsten-arc inert-gas method	Readily welded by all conventional methods	Readily welded by conventional methods; preheat to 450–550 F, postheat at 600 F
AVAILABLE FORMS	Bar, billets, forgings, plate, sheet, strip, wire [g]			
USES	Aircraft and missile turbine housings, engine mounts, landing gear, airframes and other high strength, high temperature components	High strength, thin-wall rocket motor cases, landing gear and other high strength aircraft structural components	Aircraft landing gear and other high strength components	High strength, thin-wall rocket motor cases, landing gear and other high strength aircraft structural components

[a] Properties for materials in the following conditions:
Unimach I, Vascojet: air cooled from 1850 F and double tempered at 1000 F.
Unimach UCX2: austenitized at 1700 F, oil quenched, double tempered at 500–600 F.
300-M: normalized at 1700 F, austenitized at 1600 F, oil quenched, tempered at 600 F.
D-6A: normalized at 1650 F, oil quenched, tempered at 500–700 F.
[b] 80–1200 F. [c] 80–600 F. [d] 0–600 F. [e] Tempered at 850 F. [f] Tempered at 1050 F. [g] 300-M also available as castings.

Age Hardenable Stainless Steels—Wrought

Type →	Stainless W	17-4 PH	17-7 PH	PH 15-7 Mo	17-14 Cu Mo
COMPOSITION, %	C 0.12 max, Mn 1.0 max, Si 1.0 max, Ni 7.0, Cr 17.0, Ti 1.2, Al 0.50, Fe bal	C 0.07 max, Mn 1.0 max, Si 1.0 max, Cr 16.5, Ni 4.0, Cu 4.0, Cb+Ta 0.30	C 0.09 max, Mn 1.0 max, Si 1.0 max, Cr 17.0, Ni 7.1, Al 1.0, Fe bal	C 0.09 max, Mn 1.0 max, Si 1.0 max, Cr 15.0, Ni 7.0, Mo 2.5, Al 1.0, Fe bal	C 0.12, Mn 0.75, Si 0.50, Cr 15.9, Ni 14.1, Mo 2.50, Cu 3.0, Cb 0.45, Ti 0.25, Fe bal
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.280	0.281	0.276	0.277	0.287
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	12.1	10.4	9.7	9.3	8.7
Coef of Ther Exp (70–200 F), per °F	5.5×10^{-6} [c]	6.0×10^{-6}	5.6×10^{-6}	5.6×10^{-6}	8.2×10^{-6}
Elec Res (68 F), microhm-cm	85	77	82	82	—
Magnetic Permeability (max)	101	151	82	150	—
MECHANICAL PROPERTIES [a, b]					
Mod of Elast in Tension, psi	28×10^6	28.5×10^6	29×10^6	29×10^6	28×10^6
Ten Str, 1000 psi					
Room Temp	195	195	200, 235	210, 240	86
800 F	146	157	143, 159	160, 182	73 (900 F)
1000 F	94	100	—, 93	110, 130	72
1200 F	41	59	—, —	—, —	34 (1500 F)
Yld Str (0.2% offset), 1000 psi					
Room Temp	180	180	185, 220	200, 225	42
800 F	135	138	129, 137	150, 152	27 (900 F)
1000 F	54	77	—, 76	105, 105	28
1200 F	24	42	—, —	—, —	26 (1500 F)
Elongation (in 2 in.), %					
Room Temp	3–5	13	9, 6	7, 6	45
800 F	13.5	10	6.5, 12	9.5, 8.5	35 (900 F)
1000 F	22.5	15	—, 26	21, 13	32
1200 F	40	15	—, —	—, —	29 (1500 F)
Impact Str (Charpy), ft-lb	—	19	6, 4	4, 4	26
Fatigue Str (10^6 cycles), 1000 psi	54–96	90	75 [f], 106 [f]	—	35 [e]
Compr Yld Str, 1000 psi	180	180	200, 225	217, 243	—
Shear Str, 1000 psi	120	130	136, 150	143, 160	—
Creep Str (1000 hr, 800 F), 1000 psi					
0.1%	—	50	60, 31	—, 95	24 [b]
0.2%	40 [d]	—	—, 36	—, 109	—
Rupture Str (800 F), 1000 psi					
100 Hr	31 [e]	130	110, 113	139, 174	43 [b]
1000 Hr	—	89	90, 92	137, 171	37 [b]
FABRICATING PROPERTIES					
Hot Working Temp Range, F	1700–2300	1800–2200	To 2150	—	2200
Machinability	Slightly easier than type 302	Same as type 410	Not often machined	Good	Same as types 302 and 304
Weldability	Readily welded by arc and resistance processes applicable to stainless steels				
CORROSION RESISTANCE	In general about the same corrosion and oxidation resistance as conventional stainless steels				
AVAILABLE FORMS	Bar, billets, extrusions, plate, sheet, strip, wire	Bar, billets, wire	All wrought forms	All wrought forms	All wrought forms
USES	Used where high strength-weight ratio, corrosion resistance and good strength at moderate temperatures are required. Specifically, airframe skin and structural parts			Used where high strength and corrosion resistance up to 1000 F are required. Specifically, aircraft parts	Used where good creep strength, impact strength and corrosion and oxidation resistance are needed at temperatures up to 1500 F

[a] Properties for materials in following conditions:
Stainless W: sheet solution annealed at 1850–1950 F, air cooled, aged ½ hr at 950 F, air cooled.
17-4 PH: bar solution annealed at 1900 F, oil or water quenched, aged 1 hr at 900 F, air cooled.
17-7 PH: two conditions: (1) TH 1050—sheet solution annealed at 1950 F, austenitized 90 min at 1400 F, air cooled to 50–60 F, held 30 min, aged 90 min at 1050 F; (2) RH 950—solution annealed at 1950 F, austenitized 10 min at 1750 F, air cooled, treated 8 hr at −100 F, aged 1 hr at 950 F. PH-15-7 Mo: same as 17-7 PH.
17-14 Cu Mo: solution annealed ½ hr at 2250 F, water quenched, aged 5 hr at 1350 F, water quenched.
[b] Where two sets of values are given they represent the TH 1050 and RH 950 conditions as given in the preceding note.
[c] 32–212 F. [d] 500 hr. [e] At 1000 F. [f] Vapor blasted surface. [g] 10^8 cycles at 1200 F. [h] At 1200 F.

Age Hardenable Stainless Steels—Wrought, Cast

Type →	AM-350	AM-355	Cast AM-355	Cast 17-4PH
COMPOSITION, %	C 0.10, Mn 0.80, Si 0.25, Cr 16.5, Ni 4.3, Mo 2.75, N 0.10, Fe bal	C 0.13, Mn 0.95, Si 0.25, Cr 15.5, Ni 4.3, Mo 2.75, N 0.10, Fe bal	C 0.10, Mn 0.80, Si 0.60, Cr 15.0, Ni 4.2, Mo 2.3, N 0.09, Fe bal	C 0.07, Mn 1.0, Si 1.0, Cr 15–17, Ni 3–5, Cu 2.3–3.0, Fe bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.282	0.282	0.282	0.280
Melting Temp, F	2500–2550	2500–2550	2500–2550	—
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	8.87	9.18	9.18	10.4
Coef of Ther Exp (68–212 F), per °F	6.3×10^{-6}	6.4×10^{-6}	6.4×10^{-6}	6.0×10^{-6}
Elec Res (80 F), microhm-cm	78.8	75.7	75.7	98
MECHANICAL PROPERTIES[a]				
Mod of Elast in Tension, psi				
80 F	29.4×10^6	29×10^6	29.3×10^6	28.5×10^6
600 F	25.9×10^6	26×10^6	—	—
800 F	24.3×10^6	24.6×10^6	—	—
Ten Str, 1000 psi				
Room Temp	206	219	215	170 (min)
600 F	189	210	—	—
800 F	186	198	—	158
1000 F	106	144	—	—
Yld Str (0.2% offset), 1000 psi				
Room Temp	173	181	165	140 (min)
600 F	136	152	—	—
800 F	125	139	—	138
1000 F	85	97	—	—
Elongation (in 2 in.), %				
Room Temp	13.5	12.6	15.0	6 (min)
600 F	7.0	11.5	—	—
800 F	9.5	11.0	—	—
1000 F	16.0	16.0	—	—
Impact Str (Charpy), ft-lb[b]				
Room Temp	14.1	17.1	—	17
212 F	24.5	18.5	—	—
Creep Str (1000 hr, 800 F), 1000 psi				
0.1 %	91	100	—	120 (700 F)
0.01%	23	27	—	80 (700 F)
Rupture Str (800 F), 1000 psi				
10 Hr	188	188	—	—
100 Hr	186	186	—	—
1000 Hr	183	180	—	89
FABRICATING PROPERTIES				
Hot Working Temp, F	1700–2100	1700–2100	1700–2100	1800–1850
Machinability	Similar to conventional stainless steels			
Weldability	Readily weldable by all methods used on chromium-nickel stainless steels			
CORROSION RESISTANCE	Superior to other hardenable stainless grades; offer good resistance to boiling 65% nitric, boiling citric, boiling glacial acetic, 10% oxalic (200 F), and boiling 10% phosphoric acids			Better than 12% chromium steels and approaches 18-8 stainless
AVAILABLE FORMS	Billets, bar, forgings, sheet, strip, foil, wire, welded tubing	Sheet, strip, plate, bar, forgings, tubing, wire and electrodes	Castings	Castings
USES	Structural parts requiring high strength-weight ratio, corrosion resistance and good strength at moderate temperatures	Structural parts requiring high strength, good corrosion resistance and ease of fabrication		Chemical equipment requiring strength and galling resistance

[a] Properties for materials in the following conditions:
AM-350: sheet solution treated at 1710 F ± 25 F, air cooled or water quenched, hardened 3 hr at − 100 F, hardened 3 hr at 850–1000 F, air cooled.
AM-355: same as AM-350; elevated temperature properties are for bar stock.
Cast AM-355: same as AM-350.
Cast 17-4PH: solution annealed 1 hr at 1900 F, air cooled, hardened 1 hr at 875 F, air cooled.

[b] Bar stock.

Iron-Base Superalloys (Cr-Ni)—Wrought

Type →	19-9DL	Unitemp 212	W 545	Discaloy	D-979
COMPOSITION, %	C 0.32, Mn 1.15, Si 0.55, Cr 18.5, Ni 9.0, Mo 1.40, W 1.35, Cb+Ta 0.40, Ti 0.25, Cu 0.15, Fe bal	C 0.08, Mn 0.05, Si 0.15, Cr 16.0, Ni 25.0, Ti 4.0, Al 0.15, Cb+Ta 0.50, B 0.06, Zr 0.05, Fe bal	C 0.05, Mn 1.50, Si 0.40, Cr 13.5, Ni 26.0, Mo 1.50, Ti 2.85, Al 0.20, B 0.08, Fe bal	C 0.04, Mn 0.9, Si 0.8, Cr 13.5, Ni 26.0, Ti 1.75, Mo 2.75, Al 0.07, Cu 0.05, Fe bal	C 0.05, Mn 0.50, Si 0.50, Cr 15.0, Ni 45.0, Mo 3.75, W 3.75, Ta 3.0, Al 1.0, B 0.01, Fe bal
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.287	0.286	0.285	0.288	0.295
Ther Cond (1200 F), Btu/hr/sq ft/°F/ft.	12.2	13.7	13.0	13.0	—
Melting Temp, F	2560–2615	2480	2460–2500	2516–2664	2225–2550
Coef of Ther Exp (70–1500 F), per °F	10×10^{-6}	10×10^{-6}	9.7×10^{-6}	9.6×10^{-6}	9.5×10^{-6}
Specific Heat, Btu/lb/°F	0.10	—	—	—	—
Elec Res (200 F), microhm-cm	—	91[c]	104	104	—
MECHANICAL PROPERTIES[a]					
Mod of Elast in Tension, psi					
Room Temp	29.5×10^6	29.0×10^6	28.5×10^6	28.3×10^6	28.0×10^6
1000 F	23.3×10^6	23.3×10^6	22.3×10^6	22.2×10^6	24.0×10^6
1200 F	22.0×10^6	22.0×10^6	21.0×10^6	21.0×10^6	21.0×10^6
1400 F	20.7×10^6	20.5×10^6	—	—	18.0×10^6
Ten Str, 1000 psi					
Room Temp	114	187	175	145	196
1000 F	79	—	146	125	186
1200 F	62	144	134	104	156
1400 F	50	102	83	82 (1350 F)	105
Yld Str (0.2% offset), 1000 psi					
Room Temp	71	134	125	106	142
1000 F	55	—	112	94	130
1200 F	52	122	105	91	122
1400 F	40	97	70	74 (1350 F)	94
Elongation (in 2 in.), %					
Room Temp	41	23	20	19	16
1000 F	24	—	14	16	15
1200 F	35	18	18	19	20
1400 F	35	16	34	14 (1350 F)	17
Impact Str (Charpy), ft-lb					
Room Temp	46	24–34	30	36	—
1200 F	56	—	23	35	—
Fatigue Str (10^8 cycles), 1000 psi					
Room Temp	81	—	—	55	—
1200 F	52	70	—	51	—
Rupture Str (1350 F), 1000 psi					
100 Hr	44 (1200 F)	63	60 (1300 F)	30	48[d]
1000 Hr	37 (1200 F)	43	50	25 (500 hr)	34[d]
FABRICATING PROPERTIES					
Hot Working Temp, F	1200–2150	1900–1950	1700–2100	1800–2150	1750–2100
Machinability Index[b]	40	—	—	25	—
Weldability	Excellent	Limited data	—	Limited data	—
CORROSION RESISTANCE	Excellent res to acids, exhaust gases	Excellent up to 1400 F	Excellent up to 1300 F	Excellent up to 1300 F	Excellent up to 1600 F
AVAILABLE FORMS	Billets, bar, wire, sheet, strip, tubing, forgings	Billets, bar, wire, sheet, strip	Billets, bar, strip, plate, sheet, forgings	Billets, bar, strip, plate, sheet, wire, forgings	Billets, bar, sheet, forgings
USES	Highly stressed missile and jet engine parts at elevated temperatures				

[a] Properties for material in the following conditions:
19-9DL: hot rolled bar stress relieved 8 hr at 1350 F, air cooled.
Unitemp 212: bar solution treated 2 hr at 1850 F, air cooled, aged 16 hr at 1325 F, air cooled.
W 545: bar solution treated 3 hr at 2000 F, water quenched, aged 20 hr at 1375 F and 20 hr at 1200 F, air cooled.
Discaloy: forging solution treated 2 hr at 1650 F, water quenched, aged 10 hr at 1350 F and 40 hr at 1200 F, air cooled.
D 979: bar solution treated 1 hr at 1850 F, oil quenched, aged 4 hr at 1550 F and 16 hr at 1300 F, air cooled.

[b] Based on AISI B1112 steel = 100. [c] At 70 F.

[d] Stress rupture values can be increased to 73,000 psi for 100 hr and 57,000 psi for 1000 hr (with a decrease in tensile properties) by solution treating at 2050 F.

Iron-Base Superalloys (Cr-Ni)—Wrought

Type →	A-286	V-57	16-25-6	Incoloy 901
COMPOSITION, %	C 0.08 max, Mn 1.35, Si 0.95, Cr 15.50, Ni 26.0, Mo 1.25, Ti 1.95, V 0.30, Al 0.20, Fe bal	C 0.06, Mn 0.25, Si 0.55, Cr 15.0, Ni 25.5, Mo 1.25, Ti 3.0, Al 0.25, V 0.025, Fe bal	C 0.10 max, Mn 2.0 max, Si 1.0 max, Cr 16.25, Ni 25.5, Mo 6.0, Fe bal	Cr 13.0, Ni 40.0, Ti 2.40, Mo 6.0, Fe bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.286	—	0.291	0.297
Melting Temp Range, F	2500–2600	—	—	—
Ther Cond (1100 F), Btu/hr/sq ft/°F/ft	13.7	—	15.0	—
Coef of Ther Exp (80–1400 F), per °F	10.3×10^{-6}	10.5×10^{-6}	9.4×10^{-6}	9.2×10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	—	—	—
MECHANICAL PROPERTIES[a]				
Mod of Elast in Tension, psi				
Room Temp	29.1×10^6	—	28.2×10^6	29.9×10^6
1000 F	23.5×10^6	—	—	24.2×10^6
1200 F	22.2×10^6	—	17.9×10^6	22.1×10^6
1500 F	19.8×10^6	—	10.0×10^6	—
Ten Str, 1000 psi				
Room Temp	150	172	142	175
1200 F	104	129	90	138
1400 F	64	100 (1350 F)	60	90
1500 F	37	60	47	70
Yld Str (0.2% offset), 1000 psi				
Room Temp	100	119	112	115
1200 F	88	108	75	88
1400 F	—	89 (1350 F)	50	77
1500 F	—	49	37	60
Elongation (in 2 in.), %				
Room Temp	25	24	23	—
1200 F	13	22	12	—
1400 F	19	23 (1350 F)	11	—
1500 F	69	40	9	—
Impact Str (Charpy), ft-lb				
Room Temp	60	—	15	—
1000 F	46	—	50 (1500 F)	—
Fatigue Str (10^8 cycles, 1200 F), 1000 psi	38	—	46	—
Creep Str (0.0001%/hr), 1000 psi				
1200 F	30	—	19	—
1350 F	16	—	13	—
Rupture Str (1350 F), 1000 psi				
100 Hr	35	40	28	50
1000 Hr	21	25	21	30
FABRICATING PROPERTIES				
Hot Working Temp, F	2000–2150	1950–2050	2100 (max)	1850–2200
Forgeability	Excellent	Excellent	—	Good
Machinability Index[b]	27	25	31	20
Weldability	Limited data	Limited data	Limited data	Limited data
CORROSION RESISTANCE	Excellent up to 1300 F in all atmospheres encountered in jet engine service		Good corrosion and oxidation resistance at elevated temperatures	Adequate oxidation resistance in range of 1000–1400 F
AVAILABLE FORMS	Billets, bar, sheet, strip, tubing, forgings	Billets, bars, forgings, wire, sheet	Billets, bar, sheet, rod, forgings	Sheet, bar
USES	Jet engine turbine wheels, blades, frames, casings, afterburner parts, bolts and miscellaneous hardware		Gas turbines; jet engine wheels, buckets, rotors	Jet engine wheels and disks

[a] Properties for materials in the following conditions:
A–286: bar solution treated 1 hr at 1800 F, oil quenched, aged 16 hr at 1325 F, air cooled.
16–25–6: bar solution treated 10 min at 2150 F, water quenched, cold worked 20%, stress relieved 4 hr at 1250 F.
V–57: bar solution treated 2 hr at 1800 F, oil quenched, aged 16 hr at 1350 F, air cooled.
Incoloy 901: data not available.

[b] Based on AISI B1112 steel = 100.

Iron-Base Superalloys (Cr-Ni-Co)—Cast, Wrought

Type →	Multimet, N-155	Refractaloy 26	Refractaloy 70	S-590
COMPOSITION, %	C 0.10, Mn 1.50, Si 0.70, Cr 20.75, Ni 19.85, Co 19.50, Mo 2.95, W 2.35, Cb+Ta 1.15, Ca 0.20, Fe bal	C 0.03, Mn 0.8, Si 1.0, Cr 18.0, Ni 38.0, Co 20.0, Mo 3.2, Ti 2.6, Al 0.2, Fe bal	C 0.04, Mn 2.0, Si 0.3, Cr 20.0, Ni 21.0, Co 30.0, Mo 8.0, W 4.2, Fe bal	C 0.4, Mn 1.5, Si 0.6, Cr 20.0, Ni 20.0, Co 20.0, Mo 4.0, W 4.0, Cb 4.0, Fe bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.296	0.296	0.311	0.301
Melting Temp, F	2350–2470	2450	2380	2400
Coef of Ther Exp (70–1000 F), per °F	9.1×10^{-6}	8.2×10^{-6}	8.3×10^{-6}	8.0×10^{-6}
Spec Ht (70–212 F), Btu/lb/°F	0.104	0.108	—	0.10
MECHANICAL PROPERTIES[a]				
Mod of Elast in Tension, psi				
Room Temp	28.8×10^6	30.0×10^6	—	31.1×10^6
1000 F	24.0×10^6	26.3×10^6	—	—
1200 F	21.7×10^6	25.0×10^6	—	24.6×10^6
Ten Str, 1000 psi				
Room Temp	118	154	132	142
1000 F	94	143	113	132
1200 F	74	136	112	95
1400 F	59	71 (1500 F)	69 (1500 F)	62
1600 F	39	48	48	—
Yld Str (0.2% offset), 1000 psi				
Room Temp	58	91	87	75
1000 F	40	85	77	80
1200 F	38	89	72	71
1400 F	36	66 (1500 F)	47 (1500 F)	51
1600 F	30	47	41	—
Elongation (in 2 in.), %				
Room Temp	49	19	3	21
1000 F	54	18	9	14
1200 F	28	15	11	24
1400 F	12	29 (1500 F)	30 (1500 F)	26
1600 F	15	49	33	—
Impact Str (Charpy), ft-lb				
Room Temp	65	18	—	12
1200 F	61[c]	25	—	21–23
Fatigue Str (10^8 cycles), 1000 psi				
1200 F	66[d]	54	—	—
1500 F	33[d]	37	32	33
Creep Str (1.0%, 1350 F), 1000 psi				
100 Hr	20[e]	46	25	25
1000 Hr	15[e]	37	—	20
Rupture Str (1350 F), 1000 psi				
100 Hr	28	51	33	30
1000 Hr	22	42	24	22
FABRICATING PROPERTIES				
Hot Working Temp, F	1400–1650	1600–2200	2150	2100–2250
Machinability Index[b]	15	20	20	15–20
Weldability	Good	Similar to stainless steel		—
CORROSION RESISTANCE	Good oxidation and corrosion res up to 2000 F	Excellent res to oxidizing and reducing atmospheres to 1800 F	Excellent res to oxidation up to 2200 F	Similar to stainless steel
AVAILABLE FORMS	Bar, sheet, plate, tubing, electrodes, forgings; also sand and investment castings	Bar, springs, strip, forgings	Bar, flat springs, forgings	Plate, sheet, strip, bar forgings
USES	Gas turbine blades, vanes, nozzles and other elevated temperature parts			

[a] Properties for material in the following conditions:
Multimet, N-155: solution treated 1 hr at 2200 F, air cooled.
Refractaloy 26: solution treated 1 hr at 1800–2100 F, oil quenched, aged 20–44 hr at 1350–1500 F and 4–20 hr at 1500 F, air cooled.
Refractaloy 70: solution treated 4 hr at 2350 F, oil quenched, aged 240–300 hr at 1500 F, air cooled.
S-590: solution treated 1 hr at 2250 F, water quenched, aged 16 hr at 1400 F, air cooled.
[b] Based on AISI B1112 steel = 100. [c] Reheated 2 hr at 1200 F. [d] Aged 50 hr at 1200 F. [e] Aged 2 hr at 1350 F.

Carbon Steels—Cast

Class[a] →	60,000	65,000	70,000	80,000	85,000	100,000
PHYSICAL PROPERTIES						
Density, lb/cu in.	0.283	0.283	0.283	0.283	0.283	0.283
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27	27	27
Coef of Ther Exp (70–1200 F), per °F	8.3×10^{-6}	8.3×10^{-6}	8.3×10^{-6}	8.3×10^{-6}	8.3×10^{-6}	8.3×10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11
Elec Res (68 F), microhm-cm	13–16	13–16	13–16	13–16	13–16	13–16
Magnetic?	Yes	Yes	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES[b]						
Mod of Elast in Tension, psi	30.1×10^6	30.1×10^6	30×10^6	29.9×10^6	29.9×10^6	29.7×10^6
Ten Str, 1000 psi	60[c]	65[d]	70[d]	80[e]	85[e]	100[f]
Yld Point, 1000 psi	30[c]	35[d]	38[d]	45[e]	50[e]	70[f]
Elong (in 2 in.), %	32[c]	30[d]	28[d]	26[e]	24[e]	20[f]
Red. of Area, %	55[c]	53[d]	50[d]	43[e]	40[e]	46[f]
Hardness (Brinell)	120[c]	130[d]	140[d]	160[e]	175[e]	200[f]
Impact Str (Izod), ft-lb						
70 F	30[c]	30[d]	30[d]	25[e]	20[e]	30[f]
−50 F	8[c]	12[d]	10[d]	12[e]	10[e]	15[f]
Endurance Limit, 1000 psi	25[c]	28[d]	31[d]	35[e]	38[e]	47[f]
THERMAL TREATMENT						
Annealing Temp, F	About 200 F above critical range					
Quenching Temp, F	About 100 F above critical range					
FABRICATING PROPERTIES						
Machinability Index[g]	55	60	65	70	70	65
Weldability	Can be welded by procedures used for welding wrought steels of similar composition					
CORROSION RESISTANCE	When brought into contact with moisture and air, carbon steels rust at rates that are not affected by carbon content. If salts are present, corrosion rate is increased. Attacked readily by acids, but resistant to alkalis at ordinary temperatures					
USES	Applications requiring low electrical resistivity, good magnetic properties, carburizing and case hardening, weldability	Applications requiring excellent weldability; medium strength with good machinability and high ductility	Applications requiring high strength with good machinability, toughness and excellent fatigue resistance	Applications requiring wear resistance and hardness		

[a] Tensile strength, psi.
[b] Normally expected coupon values for steel castings having tensile strength given.
[c] Annealed.
[d] Normalized.
[e] Normalized and tempered.
[f] Quenched and tempered.
[g] High speed tool steels based on AISI B1112-steel = 100.

Low Alloy Steels—Cast

Class[b] →	70,000	80,000	90,000	100,000	110,000
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.283	0.283	0.283	0.283	0.283
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27	27
Coef of Ther Exp (70–1200 F), per °F	8.0–8.3 x 10^{-6}	8.0–8.3 x 10^{-6}	8.0–8.3 x 10^{-6}	8.0–8.3 x 10^{-6}	8.0–8.3 x 10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11
Elec Res (68 F), microhm-cm	15–20	15–20	15–20	15–20	15–20
Magnetic?	Yes	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES[c]					
Mod of Elast in Tension, psi	29–30 x 10^6	29–30 x 10^6	29–30 x 10^6	29–30 x 10^6	29–30 x 10^6
Ten Str, 1000 psi	70[e]	80[e]	90[e]	100[e]	110[f]
Yld Point, 1000 psi	45	50	60	68	85
Elong (in 2 in.), %	26	24	22	20	20
Red. of Area, %	56	50	46	42	45
Hardness (Brinell)	150	170	190	209	235
Impact Str (Charpy), ft-lb					
70 F	35	30	26	22	23
–50 F	25	20	15	12	18
Endurance Limit, 1000 psi	33	38	41	45	49
THERMAL TREATMENT					
Annealing Temp, F	About 200 F above critical range				
Quenching Temp, F	About 100 F above critical range				
FABRICATING PROPERTIES					
Machinability Index[d]	65	70	70	65	60
Weldability	Can be welded by procedures used for wrought steels of similar composition				
CORROSION RESISTANCE	Similar to corrosion resistance of carbon steels				
USES	Applications requiring excellent weldability; medium strength with high toughness and good machinability; good high temperature properties		Applications requiring toughness or excellent high temperature and deep hardening properties		Applications requiring high resistance to impact; excellent low temperature properties; deep hardening; or excellent combination of strength and toughness

[a] Below 8% total alloy content.
[b] Tensile strength, psi.
[c] Normally expected coupon values for steel castings having tensile strength given.
[d] High speed tool steels based on AISI B1112 steel = 100.
[e] Normalized and tempered.
[f] Quenched and tempered.

Low Alloy Steels—Cast

Class[b] →	120,000	150,000	175,000	200,000
PHYSICAL PROPERTIES				
Density, lb/cu in	0.283	0.283	0.283	0.283
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27
Coef of Ther Exp (70–1200 F), per °F	8.0–8.3 x 10^{-6}	8.0–8.3 x 10^{-6}	8.0–8.3 x 10^{-6}	8.0–8.3 x 10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11
Elec Res (68 F), microhm-cm	15–20	15–20	15–20	15–20
Magnetic?	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES[c]				
Mod of Elast in Tension, psi	29–30 x 10^6	29–30 x 10^6	29–30 x 10^6	29–30 x 10^6
Ten Str, 1000 psi	120[f]	150[f]	175[f]	200[f]
Yld Point, 1000 psi	95	125	148	170
Elong. (in 2 in.), %	16	12	8	5
Red. of Area, %	38	25	20	11
Hardness (Brinell)	245	300	340	400
Impact Str (Charpy), ft-lb				
70 F	20	14	10	—
–50 F	16	10	6	—
Endurance Limit, 1000 psi	55	65	77	85
THERMAL TREATMENT				
Annealing Temp, F	About 200 F above critical range			
Quenching Temp, F	About 100 F above critical range			
FABRICATING PROPERTIES				
Machinability Index[d]	50	30	—	—
Weldability	Can be welded by procedures used for wrought steels of similar composition			
CORROSION RESISTANCE	Generally similar to carbon steels			
USES	Applications requiring high resistance to impact, excellent low temperature properties, deep hardening; excellent combination of strength and toughness	Applications requiring deep hardening, high strength, wear resistance, fatigue resistance	Applications requiring high strength, wear resistance, high hardness, high fatigue resistance	

[a] Below 8% total alloy content.
[b] Tensile strength, psi.
[c] Normally expected coupon values for steel castings having tensile strength given.
[d] High speed tool steels based on AISI B1112 steel = 100.
[f] Quenched and tempered.

Stainless Steels—Cast

ACI Type →	CA-15	CA-40	CB-30	CC-50
COMPOSITION, %	C 0.15 max, Mn 1.0 max, Si 1.5 max, P 0.04 max, S 0.04 max, Cr 11.5–14.0, Ni 1.0 max, Mo 0.5[a]	C 0.20–0.40, Mn 1.0 max, Si 1.50 max, P 0.04 max, S 0.04 max, Cr 11.5–14.0, Ni 1.0 max, Mo 0.5[a]	C 0.30 max, Mn 1.0 max, Si 1.0 max, P 0.04 max, S 0.04 max, Cr 18–22, Ni 2.0 max	C 0.50 max, Mn 1.0 max, Si 1.0 max, P 0.04 max, S 0.04 max, Cr 26–30, Ni 4.0 max
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.275	0.275	0.272	0.272
Melting Point, F	2750	2725	2725	2725
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	14.5	14.5	12.8	12.6
Coef of Ther Exp (70–1000 F), per °F	6.4×10^{-6}	6.4×10^{-6}	6.5×10^{-6}	6.4×10^{-6}
Spec Ht (70 F), Btu/lb/°F	0.11	0.11	0.11	0.12
Elec Res (70 F), microhm-cm	78	76	76	77
Magnetic Permeability	Ferromagnetic	Ferromagnetic	Ferromagnetic	Ferromagnetic
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	29×10^6	29×10^6	29×10^6	29×10^6
Ten Str, 1000 psi				
Annealed	—	—	95[f]	97[g]
As Cast	—	—	—	70–95
Hard. & Temp	200[c], 100[d]	220[c], 110[e]	—	—
Yld Str (0.2% offset), 1000 psi				
Annealed	—	—	60[f]	65[g]
As Cast	—	—	—	60–65
Hard. & Temp	150[c], 75[d]	165[c], 67[e]	—	—
Elong (in 2 in.), %				
Annealed	—	—	15[f]	18[g]
As Cast	—	—	—	2–15
Hard. & Temp	7[c], 30[d]	1[c], 18[e]	—	—
Hardness (Brinell)				
Annealed	—	—	195[f]	210[g]
As Cast	—	—	—	193–212
Hard. & Temp	390[c], 185[d]	470[c], 212[e]	—	—
Impact Str (Charpy, keyhole notch), ft-lb				
As Cast	—	—	—	2–45 (Izod V notch)
Hard. & Temp	15[c], 35[d]	1[c], 3[e]	—	—
THERMAL TREATMENT				
Annealing Temp, F[b]	1450–1650 f.c.	1450–1650 f.c.	1450 f.c. and 1000 a.c.	1450 f.c. or a.c.
Hardening Temp, F[b]	1800–1850 a.c. or o.q.	1800–1850 a.c. or o.q.	Practically nonhardenable by heat treatment	Nonhardenable by heat treatment
Tempering Temp, F	<600 or 1100–1500. Highest strength and corrosion resistance by tempering below 600		—	—
FABRICATING PROPERTIES				
Castability	Sections from 3/16 in. up can be cast satisfactorily. Somewhat lighter sections can be cast in some parts. Difficult-to-run thin sections and designs involving appreciable changes in section should be avoided. Normal shrinkage for these alloys is 1/4 in. per ft, except CC–50 which shrinks 1/32 in. per ft			
Weldability	Can be welded by metal arc, inert-gas arc and oxyacetylene gas methods. Metal arc most frequently used. Oxyacetylene welding not advisable because of possible reduction in corrosion resistance resulting from carbon pickup. Castings should be preheated and postheated			
CORROSION RESISTANCE	Good atmospheric corrosion resistance. Excellent resistance to many organic media in relatively mild service		Resists nitric acid, alkaline solutions, many organic chemicals, oxidizing atmospheres up to 1400 F	Excellent resistance to dilute sulfuric acid in mine waters, mixed nitric and sulfuric acids, and oxidizing acids
USES	Pump casing, bushings and liners, impellers, shafts, turbine blades, stuffing boxes	Choppers, cutting blades, cylinder liners, pump parts, steam turbine parts, molds and dies	Furnace brackets and hangers, pump parts, rabble arms, tube supports, valve bodies	Bushings, cylinder liners, pump casings and impellers, valve bodies and seats

[a] Molybdenum not intentionally added.
[b] f.c. = furnace cool, a.c. = air cool, o.q. = oil quench.
[c] Air cooled from 1800 F, tempered at 600 F.
[d] Air cooled from 1800 F, tempered at 1450 F.
[e] Air cooled from 1800 F, tempered at 1400 F.
[f] Annealed at 1450 F, furnace cooled to 1000 F, air cooled.
[g] Air cooled from 1900 F.

Stainless Steels—Cast

ACI Type →	CD-4MCu	CE-30	CF-3	CF-8	CF-20
COMPOSITION, %	C 0.04 max, Mn 1.0 max, Si 1.0 max, Cr 25–27, Ni 4.75–6.0, Mo 1.75–2.25, Cu 2.75–3.25	C 0.30 max, Mn 1.50, Si 2.0 max, P 0.04 max, S 0.04 max, Cr 26–30, Ni 8–11	C 0.03 max, Mn 1.50 max, Si 2.0 max, Cr 17–21, Ni 8–12	C 0.08 max, Mn 1.50 max, Si 2.0 max, P 0.04 max, S 0.04 max, Cr 18–21, Ni 8–11	C 0.20 max, Mn 1.50 max, Si 2.0 max, P 0.04 max, S 0.04 max, Cr 18–21, Ni 8–11
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.277	0.277	0.280	0.280	0.280
Melting Point, F	2650	2650	2625	2600	2575
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	—	—	9.2	9.2	9.2
Coef of Ther Exp (70–1000 F), per °F	6.5×10^{-6}	9.6×10^{-6}	10×10^{-6}	10.0×10^{-6}	10.4×10^{-6}
Spec Ht (70 F), Btu/lb/°F	0.12	0.14	0.12	0.12	0.12
Elec Res (70 F), microhm-cm	—	85	76	76	77.9
Magnetic Permeability	Ferromagnetic	>1.5	1.0–2.0	1.0–1.3[c]	1.01
MECHANICAL PROPERTIES[b]					
Mod of Elast in Tension, psi	29×10^6	25×10^6	27×10^6	28×10^6	28×10^6
Ten Str, 1000 psi	105, 140[d]	97	77	77	77
Yld Str (0.2% offset), 1000 psi	85, 110[d]	63	37	37	36
Elongation (in 2 in.), %	25, 15[d]	18	55	55	50
Hardness (Brinell)	260, 300[d]	170	140	140	163
Impact Str (Charpy keyhole notch), ft-lb	37, 12[d]	—	75	74	60
FABRICATING PROPERTIES					
Castability	Sections from 1/16 in. up can be cast satisfactorily. Somewhat lighter sections are also possible in some parts. Good castability of these alloys permits designs involving intricate shapes, but drastic changes in section should be avoided and uniform thickness should be maintained as far as possible				
Weldability	Can be welded by metal arc, inert-gas arc and oxyacetylene gas methods. Metal arc most frequently used. Oxyacetylene welding not advisable because of possible reduction in corrosion resistance caused by carbon pickup. Preheating not necessary, but castings should be quenched from the range 1950 to 2100 F to restore maximum corrosion resistance. This heat treatment is not always necessary, however, with CE-30 or CF-3				
CORROSION RESISTANCE	Resists strongly oxidizing media such as boiling nitric acid, sulfuric acid and sulfates, and organic acids	Particularly resistant to sulfurous acid, mixtures of dilute sulfuric and sulfurous acids, sulfuric and nitric acids, and sulfites	Similar to CD-4MCu		Similar to CD-4MCu but used under less drastic conditions
USES	Corrosion-erosion service: pump impellers, valves, digesters, processing equipment requiring higher strength than CF-8	Process equipment such as digester fittings, fractionating towers, piping, pump bodies and casings, valve bodies and parts	Autoclaves, blast furnaces, bushings, filter press plates, hardware, headers and heating coils, pump parts, spray nozzles, valve parts; CF-3 especially useful where castings cannot be heat treated after welding		Cylinder liners, pumps, return bends, rolls, circuit breaker parts, valve parts

[b] Water quenched from 2000 F.
[c] After heat treatment.
[d] Water quenched from 2000 F plus 3 hr at 900 F

continued on next page

Stainless Steels—Cast

ACI Type →	CF-3M	CF-8M, CF-12M	CF-8C	CF-16F
COMPOSITION, %	C 0.03 max, Mn 1.5 max, Si 1.5 max, Cr 17–21, Ni 9–13, Mo 2–3	C 0.08 max (CF–8M) or 0.12 max (CF–12M), Mn 1.5 max, Si 2.0 max, P 0.04 max, S 0.04 max, Cr 18–21, Ni 9–12, Mo 2–3	C 0.08 max, Mn 1.5 max, Si 2.0 max, P 0.04 max, S 0.04 max, Cr 18–21, Ni 9–12, Cb 1.0 max[b]	C 0.16 max, Mn 1.5 max, Si 2.0 max, P 0.17 max, S 0.04 max, Cr 18–21, Ni 9–12, Se 0.2–0.35, Mo 1.5 max
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.280	0.280	0.280	0.280
Melting Point, F	2550	2550	2600	2550
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	9.4	9.4	9.3	9.4
Coef of Ther Exp (70–1000 F), per °F	9.7×10^{-6}	9.7×10^{-6}	10.3×10^{-6}	9.9×10^{-6}
Spec Ht (70 F), Btu/lb/°F	0.12	0.12	0.12	0.12
Elec Res (70 F), microhm-cm	82	82	71	72
Magnetic Permeability	1.5–2.5	1.50–2.50	1.20–1.80	1.0–2.0
MECHANICAL PROPERTIES[c]				
Mod of Elast in Tension, psi	27×10^6	28×10^6	28×10^6	28×10^6
Ten Str, 1000 psi	80	80	77	77
Yld Str (0.2% offset), 1000 psi	42	42	38	40
Elongation (in 2 in.), %	50	50	39	52
Hardness (Brinell)	156–170	156–170	149	150
Impact Str (Charpy, keyhole notch), ft-lb	70	70	30	75
FABRICATING PROPERTIES				
Castability	Sections from 1/16 in. up can be cast satisfactorily. Somewhat lighter sections are also possible in some parts. Good castability of these alloys permits designs involving intricate shapes, but drastic changes in section should be avoided and uniform thickness should be maintained as far as possible			
Weldability	Can be welded by metal arc, inert-gas arc and oxyacetylene gas methods. Metal arc most frequently used. Oxyacetylene welding not advisable because of possible reduction in corrosion resistance caused by carbon pickup. Preheating not necessary, but castings should be quenched from the range 1950 to 2100 F to restore maximum corrosion resistance. This heat treatment is not always necessary, however, with CF-3M or CF-8C			
CORROSION RESISTANCE	Resists reducing media. More resistant to pitting corrosion than CF–8 in contact with chlorides. Not as resistant to boiling nitric acid as CF–8		Resists strongly oxidizing media such as boiling nitric acid, sulfuric acid and sulfates, and organic acids	Similar to CF–8C but somewhat inferior
USES	Agitators, evaporator parts, jet engine components, spray nozzles, high pressure steam valves; especially useful where castings cannot be heat treated after welding	Agitators, evaporator parts, jet engine components, spray nozzles, high pressure steam valves	Aircraft shroud assemblies, autoclaves, chemical tubing, fittings, jet engine parts, marine fittings	Bearings, bushings, fittings, pump and machinery parts

[b] Minimum is eight times carbon content. Cb + Ta: 1.35% max; minimum is ten times carbon content.
[c] Water quenched from 2000 F.

Stainless Steels—Cast

ACI Type →	CG-8M	CH-20	CK-20	CN-7M
COMPOSITION, %	C 0.08 max, Mn 1.5 max, Si 1.5 max, Cr 18–21, Ni 9–13, Mo 3–4	C 0.20 max, Mn 1.5 max, Si 2.0 max, P 0.04 max, S 0.04 max, Cr 22–26, Ni 12–15	C 0.20 max, Mn 1.5 max, Si 2.0 max, P 0.04 max, S 0.04 max, Cr 23–27, Ni 19–22	C 0.07 max, Mn 1.5 max, Si 1.5 max, P 0.04 max, S 0.04 max, Cr 19–22, Ni 27.5–30.5, Mo 1.75–2.50, Cu 3.0 min
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.281	0.279	0.280	0.289
Melting Point, F	2550	2600	2600	2650
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	9.4	8.2	8.2	12.1
Coef of Ther Exp (70–1000 F), per °F	9.7×10^{-6}	9.6×10^{-6}	9.2×10^{-6}	9.7×10^{-6}
Spec Ht (70 F), Btu/lb/°F	0.12	0.12	0.12	0.11
Elec Res (70 F), microhm-cm	82	84	90	89.6
Magnetic Permeability	1.5–2.5	1.71[c]	1.02	1.01–1.10
MECHANICAL PROPERTIES[b]				
Mod of Elast in Tension, psi	28×10^6	28×10^6	29×10^6	24×10^6
Ten Str, 1000 psi	82	88	76	69
Yld Str (0.2% offset), 1000 psi	43	50	38	31
Elong (in 2 in.), %	50	38	37	48
Hardness (Brinell)	170	190	144	130
Impact Str (Charpy, keyhole notch), ft-lb	70	30	50 (Izod V notch)	70
FABRICATING PROPERTIES				
Castability	Sections from 1/16 in. up can be cast satisfactorily. Somewhat lighter sections are also possible on some parts. Good castability permits designs involving intricate shapes, but drastic changes in section should be avoided			
Weldability	Can be welded by metal arc, inert-gas arc, and oxyacetylene gas methods. Metal arc welding most used. Oxyacetylene welding not advisable because of possible reduction in corrosion resistance resulting from carbon pickup			
	Preheating not necessary, but castings should be quenched from 2000–2100 F to restore maximum corrosion resistance			Preheating at 400 F necessary. After welding, castings should be quenched from 2000 F
CORROSION RESISTANCE	Similar to CF-8M, but preferred in reducing environments	Resistant to hot dilute sulfuric acid. Superior to CF-8 in certain media	Similar to CH-20, but better resistance at elevated temperatures	Resists sulfuric acid and many reducing chemicals. Good resistance to dilute hydrochloric acid and salt solutions
USES	Especially useful for applications in the pulp and paper industry	Digester fittings, roasting equipment, valves, pump parts	Digesters, filter press parts, fittings, jet engine parts, pumps, valves	Filter parts, heat exchanger parts, pickling rolls, hooks, racks and tanks; valve parts

[b] Water quenched from 2000 F.
[c] After heat treatment.

Heat Resistant Alloys—Cast

ACI Type →	HA	HC	HD	HE	HF
COMPOSITION, %	C 0.20 max, Mn 0.35-0.65, Si 1.00 max, P 0.04 max, S 0.04 max, Mo 0.90-1.20, Cr 8-10	C 0.50 max, Mn 1.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max[a], Cr 26-30, Ni 4 max	C 0.50 max, Mn 1.50 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max[a], Cr 26-30, Ni 4-7	C 0.20-0.50, Mn 2.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max[a], Cr 26-30, Ni 8-11	C 0.20-0.40, Mn 2.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max[a], Cr 19-23, Ni 9-12
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.279	0.272	0.274	0.277	0.280
Melting Point, F	2750	2725	2700	2650	2550
Ther Cond (212 F), Btu/hr/sq ft/ft/°F	15.2	12.6	12.6	10.0[f]	9.0
Coef of Ther Exp (70-1200 F), per °F	7.5×10^{-6}	6.4×10^{-6}	8.0×10^{-6}	9.9×10^{-6}	10.1×10^{-6}
Spec Ht (70 F), Btu/lb/°F	0.11	0.12	0.12	0.14	0.12
Elec Res (70 F), microhm-cm	70	77	81	85	80
Magnetic Permeability	Ferromagnetic	Ferromagnetic	Ferromagnetic	1.3-2.5	1.0
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	29×10^6	29×10^6	27×10^6	25×10^6	28×10^6
Ten Str, 1000 psi[b]	95[c], 107[d]	70-110, 115[e]	85, —	95, 90[e]	85, 100[e]
Yld Str (0.2% offset), 1000 psi[b]	65[c], 81[d]	65-75, 80[e]	48, —	45, 55[e]	45, 50[e]
Elong (2 in.), %[b]	23[c], 21[d]	2-19, 18[e]	16, —	20, 10[e]	35, 25[e]
Hardness (Brinell)[b]	180[c], 220[d]	190-223, —	190, —	200, 270[e]	165, 190[e]
ELEVATED TEMPERATURE PROPERTIES					
Ten Str, 1000 psi	67 (1000 F), 44 (1100 F)	—	36 (1400 F), 23 (1600 F), 15 (1800 F)	—	57 (1200 F), 35 (1400 F), 22 (1600 F)
Yld Str (0.2% offset), 1000 psi	42 (1000 F), 32 (1100 F)	—	—	—	21 (1400 F)
Elong (2 in.), %	36 (1100 F)	—	14 (1400 F), 18 (1600 F), 40 (1800 F)	—	16 (1200 F), 20 (1400 F), 22 (1600 F)
Creep Str (0.0001%/hr), 1000 psi	16 (1000 F), 7.2 (1100 F), 3.1 (1200 F)	1.3 (1400 F), 0.75 (1600 F), 0.36 (1800 F)	3.5 (1400 F), 1.9 (1600 F), 0.9 (1800 F)	4.0 (1400 F), 2.4 (1600 F), 1.4 (1800 F)	13 (1200 F), 6.0 (1400 F), 3.2 (1600 F)
Rupture Str, 1000 psi					
10 Hr	45 (1000 F)	4.6 (1400 F), 2.0 (1600 F), 1.1 (1800 F)	14 (1400 F)	—	37 (1200 F), 20 (1400 F), 10 (1600 F)
100 Hr	37 (1000 F)	3.3 (1400 F), 1.7 (1600 F), 0.85 (1800 F)	10 (1400 F), 5 (1600 F), 2.5 (1800 F)	11 (1400 F), 5.3 (1600 F), 2.5 (1800 F)	30 (1200 F), 14 (1400 F), 6.0 (1600 F)
1000 Hr	27 (1000 F)	2.3 (1400 F), 1.3 (1600 F), 0.62 (1800 F)	7 (1400 F)	—	17 (1200 F), 8.0 (1400 F), 3.8 (1600 F)
FABRICATING PROPERTIES					
Annealing Temp, F	1625	—	—	—	1900[g]
Machinability	Fair	Good	Good	Good	Good
Weldability	Weldable by all common methods. Preheating, postheating desirable		Weldable by all common methods. Preheating not required		
USES	Fan blades, furnace rollers, lehr rolls, refinery fittings, trunnions	Grate bars, dampers, kiln parts, rabble blades, salt pots, tuyeres	Brazing furnace parts, cracking equipment, furnace blowers, pouring spouts, salt pots, gas burner parts	Billet skids, burner nozzles, furnace conveyors, tube supports, soot blower elements	Electrode arms, burner tips, annealing boxes, wear plates, gas burner rings, conveyor belts, dampers

[a] Molybdenum not intentionally added. [b] As cast and heat treated values given in that order.
[c] Annealed. [d] Normalized at 1825 F, tempered at 1250 F.
[e] Aged 24 hr at 1400 F, furnace cooled. [f] At 1500 F.
[g] Before cyclic temperature service; 6 hr at 1900 F may improve life.

Heat Resistant Alloys—Cast

ACI Type →	HH		HI	HK	HL
COMPOSITION, %	C 0.20–0.50, Mn 2.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max[a], Cr 24–28, Ni 11–14, N 0.2 max		C 0.20-0.50, Mn 2.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max[a], Cr 26-30, Ni 14-18	C 0.20-0.60, Mn 2.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max[a], Cr 24-28, Ni 18-22	C 0.20-0.60, Mn 2.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max[a], Cr 28-32, Ni 18-22
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.279		0.279	0.280	0.279
Melting Point, F	2500		2550	2550	2600
Ther Cond (212F), Btu/hr/sq ft/ft/°F	8.2		10.9	8.2	8.2
Coef of Ther Exp (70–1800 F), per °F	10.5×10^{-6}		10.5×10^{-6}	10.0×10^{-6}	9.9×10^{-6}
Spec Ht (70 F), Btu/lb/°F	0.12		0.12	0.12	0.12
Elec Res (70 F), microhm-cm	75-85		—	90	94
Magnetic Permeability	1.0-1.9		1.0-1.7	1.02	1.01
MECHANICAL PROPERTIES	Type I[c]	Type II[c]			
Mod of Elast in Tension, psi	27×10^6	27×10^6	27×10^6	29×10^6	29×10^6
Ten Str, 1000 psi[b]	80, 86	85, 92	80, 90	75, 85	82, —
Yld Str, 1000 psi[b]	50, 55	40, 45	45, 65	50, 50	52, —
Elong (2 in.), %[b]	25, 11	15, 8	12, 6	17, 10	19, —
Hardness (Brinell)[b]	185, 200	180, 200	180, 200	170, 190	192, —
ELEVATED TEMPERATURE PROPERTIES					
Ten Str, 1000 psi					
1400 F	33	35	38	—	50
1600	18.5	22	26	23	30
1800 F	9.0	11	—	—	18.7
Yld Str (0.2% offset), 1000 psi					
1400 F	17	18	—	—	—
1600 F	13.5	14	—	—	—
1800 F	6.3	7.0	—	—	—
Elong (2 in.), %					
1400 F	18	12	6	—	—
1600 F	30	16	12	21	—
1800 F	45	30	—	—	—
Creep Str (0.0001% hr), 1000 psi					
1400 F	3.0	7.0	6.6	6.8	7.0
1600 F	1.7	4.0	3.6	4.2	4.3
2001 F	0.3	0.8	0.8	1.0	—
2150 F	—	—	0.15	0.2	—
Rupture Str, 1000 psi					
10 Hr 1400 F	—	20	—	23	—
10 Hr 1600 F	—	10	—	11	—
10 Hr 1800 F	4.7	6.0	—	6.5	—
100 Hr 1400 F	14	14	13	14.5	15
100 Hr 1600 F	6.4	7.5	7.5	7.8	9.2
100 Hr 2000 F	1.5	1.8	1.9	2.5	—
1000 Hr 1400 F	6.5	10	8.5	9.0	—
1000 Hr 1600 F	3.8	4.7	4.8	5.0	—
1000 Hr 2000 F	—	1.2	1.2	—	—
FABRICATING PROPERTIES					
Annealing Temp, F	1900[d]	1900[d]	—	—	—
Machinability	Fair	Fair	Fair	Good	Good
Weldability	Weldable by all common methods; no preheat or postheat required				
USES	Annealing trays, tube supports, carburizing boxes, exhaust manifolds, radiant tubes, retorts, stoker parts		Billet skids, brazing fixtures, furnace rails, lead pots, tube spacers, retorts	Heat treating fixtures, rabble arms, retorts, brazing fixtures, skid rails	Carrier fingers, enameling furnace fixtures, furnace skids, stack dampers

[a] Molybdenum not intentionally added.
[b] As cast and heat treated (aged 24 hr at 1400 F, furnace cooled), values given in that order.
[c] Partially ferritic.
[d] Before cyclic temperature service; 12 hr at 1900 F may improve life. [e] Austenitic.

continued on next page

Heat Resistant Alloys—Cast

ACI Type →	HN	HT	HU	HW	HX
COMPOSITION, %	C 0.20-0.50, Mn 2.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max[a], Cr 19-23, Ni 23-27	C 0.35-0.75, Mn 2.00 max, Si 2.50 max, P 0.04 max, S 0.04 max, Mo 0.5 max[a], Cr 13-17, Ni 33-37	C 0.35-0.75, Mn 2.00 max, Si 2.50 max, P 0.04 max, S 0.04 max, Mo 0.5 max[a], Cr 17-21, Ni 37-41	C 0.35-0.75, Mn 2.00 max, Si 2.50 max, P 0.04 max, S 0.04 max, Mo 0.5 max[a], Cr 10-14, Ni 58-62	C 0.35-0.75, Mn 2.00 max, Si 2.50 max, P 0.04 max, S 0.04 max, Mo 0.5 max[a], Cr 15-19, Ni 64-68
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.283	0.286	0.290	0.294	0.294
Melting Point, F	2500	2450	2450	2350	2350
Ther Cond (212F), Btu/hr/sq ft/ft/°F	—	7.7	—	7.7	—
Coef of Ther Exp (70–1800 F), per °F	—	9.8×10^{-6}	9.6×10^{-6}	8.8×10^{-6}	9.2×10^{-6}
Spec Ht (70 F), Btu/lb/°F	0.11	0.11	0.11	0.11	0.11
Elec Res (70 F), microhm-cm	—	100	105	112	—
Magnetic Permeability	1.10	1.10-2.00	1.10-2.00	16.0	2.0
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	27×10^6	27×10^6	27×10^6	25×10^6	25×10^6
Ten Str, 1000 psi[b]	68, —	70, 75[c]	70, 73[e]	68, 84[f]	65, 73[e]
Yld Str, 1000 psi[b]	38, —	40, 45[c]	40, 43[e]	36, 52[f]	36, 44[e]
Elong (2 in.), %[b]	17, —	10, 5[c]	9, 5[e]	4, 4[f]	9, 9[e]
Hardness (Brinell)[b]	160, —	180, 200[c]	170, 190[e]	185, 205[f]	176, 185[e]
ELEVATED TEMPERATURE PROPERTIES					
Ten Str, 1000 psi					
1400 F	—	35	40	32	—
1600 F	—	18.8	19.6	19	20.5
1800 F	—	11	10.0	10	10.7
Yld Str (0.2% offset), 1000 psi					
1400 F	—	26	—	23	—
1600 F	—	15	—	15	17.5
1800 F	—	8.0	6.2	8.0	6.9
Elong (2 in.), %					
1400 F	—	10	—	—	—
1600 F	—	26	20	—	48
1800 F	—	28	28	40	40
Creep Str (0.0001%/hr), 1000 psi					
1400 F	—	8.0	8.5	6.0	6.4
1600 F	6.3	4.5	5.0	3.0	3.2
2000 F	0.9	0.5	0.6	—	0.6
2150 F	—	0.15	—	—	—
Rupture Str, 1000 psi					
10 Hr, 1400 F	—	—	—	16	18
10 Hr, 1600 F	—	11	—	8.2	10
10 Hr, 2000 F	—	—	—	—	2.5
100 Hr, 1400 F	—	18	15	10	13
100 Hr, 1600 F	9.5	8.5	8.0	6.0	6.7
100 Hr, 2000 F	2.5	2.5	—	—	1.7
1000 Hr, 1400 F	—	12.5	—	7.8	—
1000 Hr, 1600 F	6.5	7.0	6.0	4.5	4.0
1000 Hr, 2000 F	0.9	1.8	—	—	0.9
FABRICATING PROPERTIES					
Annealing Temp, F	—	1900[d]	1900[d]	—	—
Machinability	Good	Good	Good	Good	Good
Weldability	Weldable by all common methods; no preheat or postheat required				
USES	Brazing fixtures, chain, nozzles, furnace parts, radiant tubes, tube supports	Air ducts, carburizing boxes, cyanide pots, glass molds, lead pots	Articulated trays, burner tubes, lead pots, cyanide pots, muffles	Cyanide pots, gas retorts, electric heating elements, hearth plates	Autoclaves, calciner tubes, furnace parts, salt bath electrodes, muffles

[a] Molybdenum not intentionally added. [b] As cast and heat treated values given in that order.
[c] Aged 24 hr at 1400 F, air cooled. [d] Before cyclic temperature service; 6 hr at 1900 F may improve life.
[e] Aged 24 hr at 1800 F, air cooled. [f] Aged 48 hr at 1800 F, furnace cooled.

Standard Tool Steels—Wrought

AISI Type →	Water Hardening Tool Steels (W)					Shock Resisting Tool Steels (S)			
	W1, W2	W3	W4	W5	W6, W7	S1	S2	S3	S4, S5
COMPOSITION, %	C 0.60–1.40, V 0.25 (W2)	C 1.00, V 0.50	C 0.60–1.40, Cr 0.25	C 1.10, Cr 0.50	C 1.00, Cr 0.25–0.50, V 0.20–0.25	C 0.50, Cr 1.50, W 2.50	C 0.50, Si 1.00, Mo 0.50	C 0.50, Cr 0.75, W 1.00	C 0.55 Si, 2.00, Mn 0.80, Mo 0.40 (S5)
HEAT TREATMENTS									
Forging Temp, F	1800–1950	1800–1950	1800–1950	1800–1950	1800–1950	1850–2050	1850–2050	1850–2050	1850–2050
Anneal Temp, F	1360–1450	1360–1450	1360–1450	1360–1450	1360–1450	1450–1500	1400–1450	1450–1500	1400–1450
Hard. Temp, F	1400–1550	1400–1550	1400–1550	1400–1550	1400–1550	1650–1800	1550–1650	1500–1600	1600–1750
Quench Medium[a]	B or W	B or W	B or W	B or W	B or W	O	B or W	B or W	O or W
Temper Temp, F	300–650	300–650	300–650	300–650	300–650	400–1200	300–800	300–600	350–800
Hardness, Rockwell	C65–50	C65–50	C65–50	C65–50	C65–50	C58–40	C60–50	C59–50	C60–50
SERVICE PROPERTIES[b]									
Depth of Hard.	Shallow	Shallow	Shallow	Shallow	Shallow	Medium	Medium	Medium	Medium
Nondeformability	Poor	Poor	Poor	Poor	Poor	Fair	Poor	Poor	Poor-fair
Safety in Hard.	Fair	Fair	Fair	Fair	Fair	Good	Poor	Poor	Poor-good
Toughness	Good	Good	Good	Good	Good	Very good	Best	Good	Best
Wear Res	Fair-good	Fair-good	Fair-good	Fair-good	Fair-good	Fair	Fair	Fair	Fair
Machinability	Best	Best	Best	Best	Best	Fair	Fair	Fair	Fair
Res to Decarb	Best	Best	Best	Best	Best	Fair-good	Poor	Fair	Poor
REMARKS	Shallow hardening, hard case, tough core; subject to distortion during heat treatment; do not retain properties above about 350 F					Better toughness, less wear resistance than W grades; can be carburized for greater hardness and wear resistance; subject to distortion during heat treatment			
TYPICAL USES	All types of tools and dies for short runs, especially cold heading dies					Punching, shearing or trimming dies			

[a] B = brine; W = water; O = oil.
[b] Values on this and next four pages are relative to all tool steels covered.

continued on next page

Standard Tool Steels—Wrought

AISI Type →	Cold Work Tool Steels—Oil Hardening (O)			Cold Work Tool Steels—Air Hardening (A)			
	O1	O2	O7	A2	A4	A5	A6
COMPOSITION, %	C 0.90, Mn 1.00, Cr 0.50, W 0.50	C 0.90, Mn 1.00	C 1.20, Cr 0.75, W 1.75	C 1.00, Cr 5.00, Mo 1.00	C 1.00, Mn 2.00, Cr 1.00, Mo 1.00	C 1.00, Mn 3.00, Cr 1.00, Mo 1.00	C 0.70, Mn 2.00, Cr 1.00, Mo 1.00
HEAT TREATMENTS							
Forging Temp, F	1800–1950	1800–1925	1800–2000	1850–2000	1850–2000	1850–2000	1400–2050
Anneal Temp, F	1400–1450	1375–1425	1450–1500	1550–1600	1360–1400	1360–1400	1350–1375
Hard Temp, F	1450–1500	1400–1475	1450–1625	1700–1800	1500–1600	1450–1550	1525–1600
Quench Medium[a]	O	O	O or W	A	A	A	A
Temper Temp, F	300–500	300–500	325–550	350–1000	300–800	300–800	300–800
Hardness, Rockwell	C62–57	C62–57	C64–58	C62–57	C62–54	C60–54	C60–54
SERVICE PROPERTIES							
Depth of Hard.	Medium	Medium	Medium	Deep	Deep	Deep	Deep
Nondeformability	Very good	Very good	O: Very good W: Poor	Best	Best	Best	Best
Safety in Hard.	Very good	Very good	O: Very good W: Poor	Best	Best	Best	Best
Toughness	Fair	Fair	Fair	Fair	Fair	Fair	Fair
Wear Res	Good	Good	Good	Very good	Good	Good	Good
Machinability	Good	Good	Good	Fair	Fair-poor	Fair-poor	Fair-poor
Res to Decarb	Good	Good	Good	Fair	Good-fair	Good-fair	Good-fair
REMARKS AND USES	Better hardenability and less distortion than W types; dies of all types			Less distortion, better safety in hardening than O types; dies of all types			

AISI Type →	Cold Work Tool Steels—High Carbon-High Chromium (D)						
	D1	D2	D3	D4	D5	D6	D7
COMPOSITION, %	C 1.00, Cr 12.00, Mo 1.00	C 1.50, Cr 12.00, Mo 1.00	C 2.25, Cr 12.00	C 2.25, Cr 12.00, Mo 1.00	C 1.50, Cr 12.00, Mo 1.00, Co 3.00	C 2.25, Si 1.00, Cr 12.00, W 1.00	C 2.35, Cr 12.00, Mo 1.00, V 4.00
HEAT TREATMENTS							
Forging Temp, F	1850–2000	1850–2000	1850–2000	1850–2000	1850–2000	1850–2000	2050–2125
Anneal Temp, F	1600–1650	1600–1650	1600–1650	1600–1650	1600–1650	1600–1650	1600–1650
Hard. Temp, F	1775–1850	1800–1875	1700–1800	1775–1850	1800–1875	1700–1750	1850–1950
Quench Medium[a]	A	A	O	A	A	O	A
Temper Temp, F	400–1000	400–1000	400–1000	400–1000	400–1000	400–1000	300–1000
Hardness, Rockwell	C61–54	C61–54	C61–54	C61–54	C61–54	C61–54	C65–58
SERVICE PROPERTIES							
Depth of Hard.	Deep	Deep	Deep	Deep	Deep	Deep	Deep
Nondeformability	Best	Best	Very good	Best	Best	Very good	Best
Safety in Hard.	Best	Best	Good	Best	Best	Good	Best
Toughness	Fair	Poor	Poor	Poor	Poor	Poor	Poor
Wear Res	Very good	Best	Best	Best	Best	Best	Best
Machinability	Poor	Poor	Poor	Poor	Poor	Poor	Poor
Res to Decarb	Fair	Fair	Fair	Fair	Fair	Fair	Fair
REMARKS AND USES	Very wear resistant, difficult to machine; little distortion during heat treatment; long runs in all types of tools and dies						

[a] A = air; O = oil; W = water.

Standard Tool Steels—Wrought

AISI Type →	Hot Work Tool Steels (H)						
	Chromium-Base						Tungsten-Base
	H11	H12	H13	H14	H15	H16	H20, H21
COMPOSITION, %	C 0.35, Cr 5.00, Mo 1.50, V 0.40	C 0.35, Cr 5.00, Mo 1.50, W 1.50, V 0.40	C 0.35, Cr 5.00, Mo 1.50, V 1.00	C 0.40, Cr 5.00, W 5.00	C 0.40, Cr 5.00, Mo 5.00	C 0.55, Cr 7.00, W 7.00	C 0.35, Cr 2.00–3.50, W 9.00
HEAT TREATMENTS							
Forging Temp, F	1950–2100	1950–2100	1950–2100	1950–2100	1900–2100	1950–2150	1950–2150
Anneal Temp, F	1550–1650	1550–1650	1550–1650	1600–1650	1550–1600	1600–1650	1600–1650
Hard. Temp, F	1825–1875	1825–1875	1825–1900	1850–1950	2100–2300	2050–2150	2000–2200
Quench Medium[a]	A	A	A	A	A or O	A or O	A or O
Temper Temp, F	1000–1200	1000–1200	1000–1200	1100–1200	1100–1200	1050–1250	1100–1250
Hardness, Rockwell	C54–38	C55–38	C53–38	C47–40	C49–36	C60–45	C54–36
SERVICE PROPERTIES							
Depth of Hard	Deep	Deep	Deep	Deep	Deep	Deep	Deep
Nondeformability	Very good	Very good	Very good	Good	A: Good O: Fair	Good	A: Good O: Fair
Safety in Hard	Best	Best	Best	Best	Fair	Good	Good
Toughness	Good	Good	Good	Good	Good	Good	Good
Wear Res	Fair	Fair	Fair	Fair	Fair	Fair	Fair-good
Machinability	Fair	Fair	Fair	Fair	Fair	Fair	Fair
Res to Decarb	Fair	Fair	Fair	Fair	Poor	Fair	Fair
REMARKS AND USES	Little distortion in heat treatment; dies for die casting, forging, extrusion, punching, etc. for use at temp up to 900 F						Some distortion; dies up to 1100 F

AISI Type →	Hot Work Tool Steels (cont'd)							
	Tungsten-Base (cont'd)					Molybdenum-Base		
	H22	H23	H24	H25	H26	H41	H42	H43
COMPOSITION, %	C 0.35, Cr 2.00, W 11.00	C 0.30, Cr 12.00, W 12.00	C 0.45, Cr 3.00, W 15.00	C 0.25, Cr 4.00, W 15.00	C 0.50, Cr 4.00, W 18.00, V 1.00	C 0.65, Cr 4.00, Mo 8.00, W 1.50, V 1.00	C 0.60, Cr 4.00, Mo 5.00, W 6.00, V 2.00	C 0.55, Cr 4.00, Mo 8.00, V 2.00
HEAT TREATMENTS								
Forging Temp, F	1950–2150	1950–2150	1950–2150	1950–2150	1950–2150	1900–2050	1900–2050	1900–2050
Anneal Temp, F	1600–1650	1600–1650	1600–1650	1600–1650	1600–1650	1500–1600	1550–1650	1500–1600
Hard. Temp, F	2000–2200	2200–2325	2000–2250	2100–2300	2150–2300	2000–2175	2050–2225	2000–2175
Quench Medium[a]	A or O	A or O	A or O	A or O	S, O or A	O, A or S	O, A or S	O, A or S
Temper Temp, F	1100–1250	1200–1500	1050–1200	1050–1250	1050–1250	1050–1200	1050–1200	1050–1200
Hardness, Rockwell	C52–39	C47–30	C55–45	C44–35	C58–43	C60–50	C60–50	C58–45
SERVICE PROPERTIES								
Depth of Hard	Deep	Deep	Deep	Deep	Deep	Deep	Deep	Deep
Nondeformability	A: Good O: Fair	A: Good O: Fair	A: Good O: Fair	A: Good O: Fair	S, A: Good O: Fair	S, A: Good O: Fair	S, A: Good O: Fair	S, A: Good O: Fair
Safety in Hard	Good	Good	Good	Good	Good	Fair	Fair	Fair
Toughness	Good	Fair	Fair	Good	Fair	Poor	Poor	Poor
Wear Res	Fair-good	Fair-good	Good	Fair	Good	Good	Good	Good
Machinability	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair
Res to Decarb	Fair	Fair	Fair	Fair	Fair	Poor	Fair	Poor
REMARKS AND USES	Tendency to distort during heat treatment; more resistant to heat than chromium-base but more susceptible to thermal shock; dies for die casting, forging, extrusion, punching, etc. at temp up to 1100 F. H24, H25 and H26 may be used at temp above 1100 F							

[a] A = air; O = oil; S = salt.

continued on next page

Standard Tool Steels—Wrought

AISI Type →	High Speed Tool Steels—Tungsten-Base (T)							
	T1, T2, T3	T4	T5	T6	T7	T8	T9	T15
COMPOSITION, %	C 0.70–1.05, Cr 4.00, V 1.00–3.00, W 18.00	C 0.75, Cr 4.00, W 18.00, V 1.00, Co 5.00	C 0.80, Cr 4.00, W 18.00, V 2.00, Co 8.00	C 0.80, Cr 4.50, W 20.00, V 1.50, Co 12.00	C 0.75, Cr 4.00, W 14.00, V 2.00	C 0.75, Cr 4.00, W 14.00, V 2.00, Co 5.00	C 1.20, Cr 4.00, W 18.00, V 4.00	C 1.50, Cr 4.00, W 12.00, V 5.00, Co 5.00
HEAT TREATMENTS								
Forging Temp, F	1950–2150	1950–2150	1950–2150	1950–2150	1950–2150	1950–2150	1950–2150	1950–2150
Anneal Temp, F	1600–1650	1600–1650	1600–1650	1600–1650	1600–1650	1600–1650	1600–1650	1600–1650
Hard. Temp, F	2250–2375	2300–2375	2325–2400	2325–2400	2300–2350	2300–2375	2275–2325	2200–2300
Quench Medium[a]	O, A or S	O, A or S	O, A or S	O, A or S	O, A or S	O, A or S	O, A or S	O, A or S
Temper Temp, F	1000–1100	1000–1100	1000–1100	1000–1100	1000–1100	1000–1100	1000–1100	1000–1200
Hardness, Rockwell	C66–60	C66–62	C65–60	C65–60	C65–60	C65–60	C66–61	C68–63
SERVICE PROPERTIES								
Depth of Hard.	Deep	Deep	Deep	Deep	Deep	Deep	Deep	Deep
Nondeformability	Good	Good	Good	Good	Good	Good	Good	Good
Safety in Hard.	Good	Fair	Fair	Fair	Good	Fair	Fair	Fair
Toughness	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor
Wear Res	Very good	Very good	Very good	Very good	Very good	Very good	Best	Best
Machinability	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair
Res to Decarb	Good	Fair	Poor	Poor	Good	Fair	Good	Fair
REMARKS AND USES	Difficult to machine and grind; generally used as cutting tools							

AISI Type →	High Speed Tool Steels—Molybdenum-Base (M)								
	M1	M2	M3, M4	M6	M7	M8	M10	M15	M30, M34, M35, M36
COMPOSITION, %	C 0.80, Cr 4.00, Mo 8.00, W 1.50, V 1.00	C 0.80, Cr 4.00, Mo 5.00, W 6.00, V 2.00	C 1.00–1.30, Cr 4.00, Mo 4.50–5.00, W 5.50–6.00, V 2.70–4.00	C 0.80, Cr 4.00, Mo 5.00, W 4.00, V 1.50, Co 12.00	C 1.00, Cr 4.00, Mo 8.75, W 1.75, V 2.00	C 0.80, Cr 4.00, Mo 5.00, W 5.00, V 1.50, Cb 1.25	C 0.85, Cr 4.00, Mo 8.00, V 2.00	C 1.50, Cr 4.00, Mo 3.50, W 6.50, V 5.00, Co 5.00	C 0.80–0.90, Cr 4.00, V 1.25–2.00, W 2.00–6.00, Mo 5.00–8.00, Co 5.00–8.00
HEAT TREATMENTS									
Forging Temp, F	1900–2100	1900–2100	1900–2100	1900–2100	1900–2100	1900–2100	1900–2100	1900–2100	1900–2100
Anneal Temp, F	1500–1600	1600–1650	1600–1650	1600	1500–1600	1550–1600	1500–1600	1600–1650	1600–1650
Hard. Temp, F	2150–2225	2175–2250	2200–2250	2150–2200	2150–2240	2200–2300	2150–2225	2175–2250	2200–2275
Quench Medium[a]	O, A or S	O, A or S	O, A or S	O, A or S	O, A or S	O, A or S	O, A or S	O, A or S	O, A or S
Temper Temp, F	1000–1100	1000–1100	1000–1100	1000–1100	1000–1100	1000–1100	1000–1100	1000–1200	1000–1100
Hardness, Rockwell	C65–60	C65–60	C66–61	C66–61	C66–61	C65–60	C65–60	C68–63	C65–60
SERVICE PROPERTIES									
Depth of Hard.	Deep	Deep	Deep	Deep	Deep	Deep	Deep	Deep	Deep
Nondeformability	Good	Good	Good	Good	Good	Good	Good	Good	Good
Safety in Hard.	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair
Toughness	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor
Wear Res	Very good	Very good	Very good-best	Very good	Very good	Very good	Very good	Best	Very good
Machinability	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair
Res to Decarb	Poor	Fair	Fair	Poor	Poor	Fair	Poor	Fair	Poor
REMARKS AND USES	Tend to decarburize more readily than tungsten-base tool steels; most common high speed cutting tool materials								

[a] O = oil; A = air; S = salt.

Standard Tool Steels—Wrought

AISI Type →	Special Purpose Tool Steels—Low Alloy (L)					Special Purpose—Carbon-Tungsten (F)		
	L1, L2	L3, L4	L5	L6	L7	F1	F2	F3
COMPOSITION, %	C 0.50–1.10, Cr 1.00–1.25, V 0.20 (L2)	C 1.00, Mn 0.60 (L4), Cr 1.50, V 0.20–0.25	C 1.00, Mn 1.00, Cr 1.00, Mo 0.25	C 0.70, Cr 0.75, Ni 1.50, Mo 0.25	C 1.00, Mn 0.35, Cr 1.40, Mo 0.40	C 1.00, W 1.25	C 1.25, W 3.50	C 1.25, Cr 0.75, W 3.50
HEAT TREATMENTS								
Forging Temp, F	1800–2000	1800–2000	1800–2000	1800–2000	1800–2000	1800–2000	1800–2000	1800–2000
Anneal Temp, F	1400–1475	1425–1500	1425–1475	1400–1450	1450–1500	1400–1475	1450–1500	1450–1500
Hard. Temp, F	1450–1700	1425–1600	1450–1600	1450–1550	1500–1600	1450–1600	1450–1600	1450–1600
Quench Medium*	O or W	O or W	O	O	O	W or B	W or B	W, B or O
Temper Temp, F	300–1000	300–600	300–600	300–1000	300–600	300–500	300–500	300–500
Hardness, Rockwell	C64–45	C64–56	C64–56	C62–45	C64–56	C64–60	C66–62	C66–62
SERVICE PROPERTIES								
Depth of Hard.	Medium	Medium	Medium	Medium	Medium	Shallow	Shallow	Shallow
Nondeformability	Fair-poor	Fair-poor	Good	Good	Good	Poor	Poor	Poor
Safety in Hard.	Fair-poor	Good-poor	Good	Good	Good	Poor	Poor	Poor
Toughness	Very good-fair	Fair	Fair	Very good	Fair	Poor	Poor	Poor
Wear Res	Good-fair	Fair	Good	Fair	Good	Good	Very good	Very good
Machinability	Good	Good	Good	Fair	Good	Good	Fair	Fair
Res to Decarb	Good	Good	Good	Good	Good	Good	Good	Good
REMARKS AND USES	Deeper hardening characteristics than W grades and about same properties as O1 and O2, but greater tendency to distort; all types of dies					Very good abrasion resistance with consequent difficulty in grinding; generally limited to wire, bar or tube cold-drawing die and finishing tools		

AISI Type →	Special Purpose Tool Steels—Mold Steels (P)						
	P1	P2	P3	P4	P5	P6	P20
COMPOSITION, %	C 0.10	C 0.07, Cr 2.00, Ni 0.50, Mo 0.20	C 0.10, Cr 0.60, Ni 1.25	C 0.07, Cr 5.00	C 0.10, Cr 2.25	C 0.10, Cr 1.50, Ni 3.50	C 0.30, Cr 0.75, Mo 0.25
HEAT TREATMENTS							
Forging Temp, F	1450–1550 or 2200–2350	1850–2050	1850–2050	1850–2050	1850–2050	1950–2150	1850–2050
Anneal Temp, F	1350–1650	1350–1500	1350–1500	1600–1650	1550–1600	1550	1400–1450
Hard. Temp, F	1450–1475	1525–1550	1475–1525	1775–1825	1550–1600	1450–1500	1500–1600
Quench Medium*	W or B	O	O	A	O or W	O	O
Temper Temp, F	300–500	300–500	300–500	300–500	300–500	300–450	300–500
Hardness, Rockwell	C64–58	C64–58	C64–58	C64–58	C64–50	C58–61	C64–58
SERVICE PROPERTIES							
Depth of Hard.	Shallow	Shallow	Shallow	Shallow	Shallow	Deep	Medium
Nondeformability	Poor	Good	Good	—	Good	Good	Good
Safety in Hard.	Fair	Good	Good	—	Good	Good	Good
Toughness	Good	Good	Good	—	Good	Good	Good
Wear Res	Good	Good	Good	—	Good	Good	Fair-good
Machinability	Poor	Good	Fair	—	Fair	Fair	Good
Res to Decarb	Good	Good	Good	—	Good	Good	Good
REMARKS AND USES	P1 is easily hubbed, has low cure hardness, is subject to distortion; P4 and P5 more difficult to hub but relatively nondeforming; P2, P3 and P6 very difficult to hub; primarily as plastic mold steels						

* W = water; B = brine; O = oil; A = air.

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Wherever metals are being cast, forged, or fabricated, the important factor of reliability can be assured by specifying RxMet brand alloys. Whether we ship shot for making castings, billets for forging, or special welding rod, the RxMet label on the alloy means more consistent performance in the finished product.

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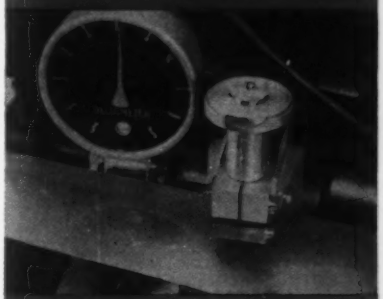

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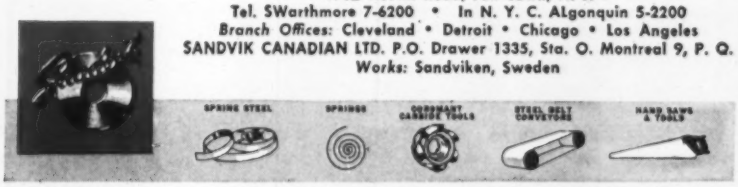

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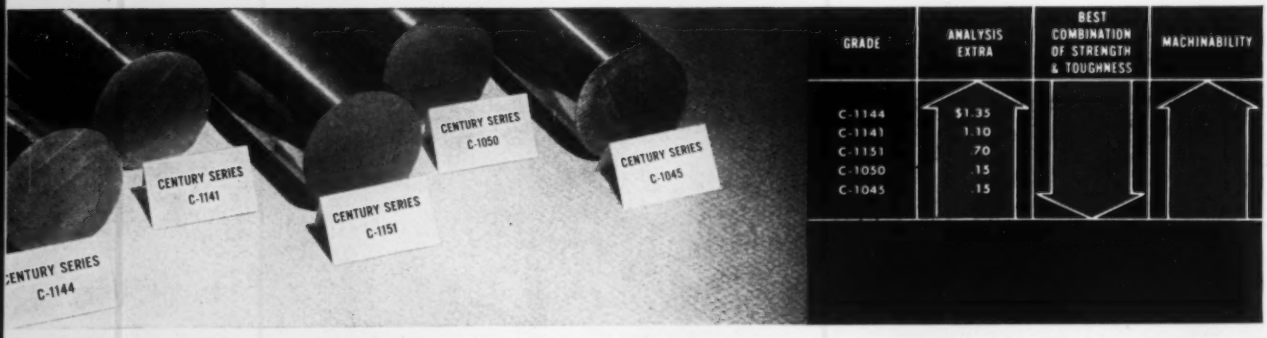
ELECTRO PAINTLOK® STEEL SHEETS. For production of their top line shower cabinets, Vogt Brothers Mfg. Company, Louisville, Ky, needed sheets that would take and hold paint exceptionally well, because the units are subjected to soap, hot and cold water, bumps and knocks. The solution: Republic Electro Paintlok Steel Sheets. Paintlok sheets are zinc coated electrolytically, then chemically treated to provide an inert phosphate surface film. Result: a firm mechanical bonding of paint, lacquer, or enamel to steel. In die forming, brake forming, and piercing operations, Vogt found that Paintlok is easy to fabricate, too.

If getting a good, tight painted finish is your problem, it will pay you to investigate Republic Electro Paintlok. Mail coupon for data.



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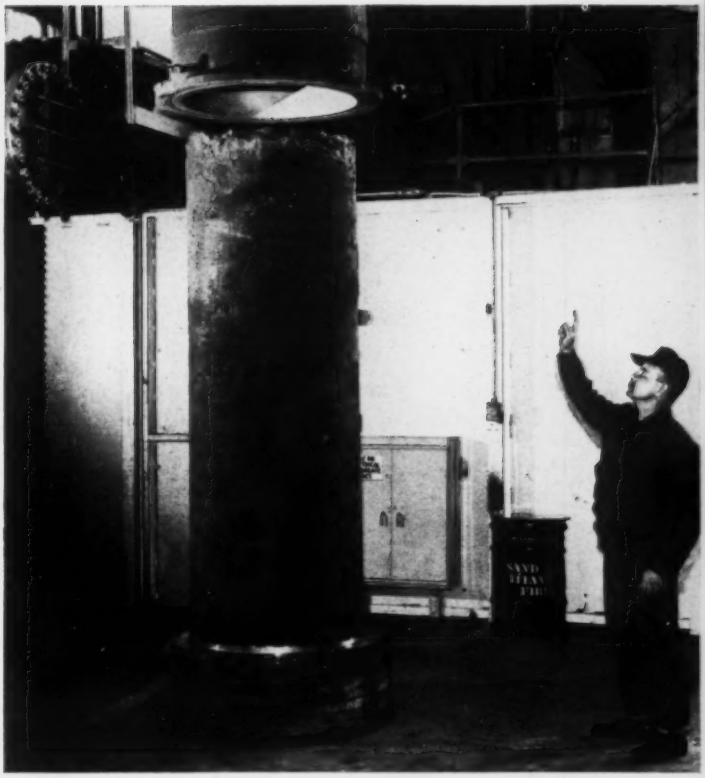
Republic Stainless Metallurgists are at your service, where and when you need them—to help you select, apply, and process the stainless steel best suited to your requirements. Send for complete information.

For more information, circle No. 549



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A-L ANSWERS YOUR QUESTIONS ON VACUUM MELTED STEELS AND ALLOYS

Q. Where are vacuum melted alloys best suited?

A. For exacting applications—including materials for rockets, missiles, and jet engines. And other places where expensive machined parts are involved. In highly stressed parts where failure is highly costly. Where increased reliability is vital.

Q. What are the advantages of A-L vacuum melted alloys?

A. You get parts with optimum quality for critical applications—higher mechanical properties, better fatigue strength, improved toughness, and better transverse ductility. You also get maximum insurance against internal defects through improved cleanliness and decreased gas content. And hot and cold workability are improved, the material is more homogeneous, and properties are better.

Q. How are these metals made?

A. A-L uses all three of the vacuum melting processes. Consumable electrode vacuum arc remelting is used to produce A-L Consutrode® steels and alloys in ingots up to 20,000 pounds in weight. Induction vacuum melting is used to produce 2,000 pound heats of Allegheny Ludlum Invac materials. And remelting Invac electrode stock by the consumable electrode process produces A-L Invacutrode steels and alloys that have the best possible combination of chemistry control, cleanliness, and homogeneity.

Q. Specifically, what metals are available in A-L's premium quality melting?

A. Most of the steels and special alloys—low alloy steels, bearing steels, stainless steels, tool and die steels, and high temperature steels and alloys.

Q. In what forms are these A-L special steels available?

A. In all commercial mill forms—plates, sheet, strip, billet, bar, wire, tubes, and even extrusions.

Q. How do these vacuum melted alloys compare in cost with ordinary alloys?

A. Naturally vacuum melting costs more. Consutrode alloys are the least expensive, followed by Invac alloys and Invacutrode alloys. Their use is economically justified by the improvement of quality in the finished part, the quality required by the severity of the manufacturing process involved, and the increase in the yield of sound parts.

Q. Where can I get more information?

A. Ask your A-L representative for your copy of "Modern Melting at Allegheny Ludlum." It gives technical data on the new melting techniques and quality improvements in materials. Or write: *Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pennsylvania. Address Dept. MI-S.*

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PIONEERING on the Horizons of Steel

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The how *and* why *of developing equipment for specific operations . . .*

1 AUTOMATING THE MANUFACTURING PROCESS

by GEORGE F. HAWLEY, *Vice President of Development and Engineering, Automation Engineering Laboratories, Inc.*
1959, 176 pages, $4.95

THE EMINENTLY sound ideas which this book presents merit the attention of all concerned with the use and development of special automatic machinery. It presents in practical terms some of the mechanical problems involved in developing automatic equipment for specific operations, such as assembly of components, packaging of individual products, bottle capping, feeding, etc. Management and production personnel will gain a greater appreciation for the problems encountered in developing successful machines, while designers and development engineers will find a machine development procedure which, if followed, should minimize their failures.

Orients processors in new methods . . .

2 VACUUM PROCESSING IN METALWORKING

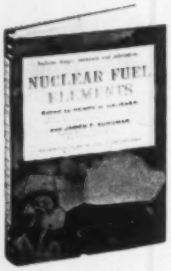
by J. WESLEY CABLE, *Consulting Engineer*
1960, 256 pages, $5.50

THE RELATIVELY new field of vacuum technology receives complete, practical treatment here. The book encompasses the complete range of operations in the metalworking field. The first few chapters cover the general phases of vacuum technology, such as the means of producing low pressures and their measurement. Following these, the author devotes each subsequent chapter to a particular phase of vacuum processing. He also includes the latest developments, among them electron beam heating. In general, the aim of the book is to present vacuum technology in a descriptive manner, rather than in a highly technical form.

Includes design, materials and fabrication . . .

3 NUCLEAR FUEL ELEMENTS

edited by HENRY H. HAUSNER, *Adjunct Professor, Brooklyn Polytechnic Institute and* JAMES F. SCHUMAR, *Associate Director, Metallurgy Division, Argonne National Laboratory*
1959, 432 pages, $12.50

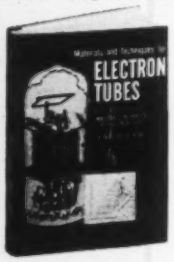


CONTAINS the papers presented at the First International Symposium on Nuclear Fuel Elements held at Columbia University in January 1959. This book is the first to deal exclusively with the nuclear fuel elements. The twenty chapters include first-hand information from scientists in the U.S. and European countries who have worked on the development, design and fabrication of fuel elements. These scientists describe their own experiences. Among the individual topics presented by each chapter are discussions of the use of the fuel elements for reactors of the future, the standardization of certain types of elements, cost analysis for low-cost fabrication and reprocessing, metallic fuel elements made from uranium, thorium and plutonium, dispersion-type fuel elements, high-temperature fuel elements, and the behavior of fuel elements under reactor operating conditions.

Complete revision of a standard work . . .

4 MATERIALS AND TECHNIQUES FOR ELECTRON TUBES

by WALTER H. KOHL, *Senior Engineering Staff, Sylvania Electric Products, Inc., a Division of General Telephone & Electronics Corporation, General Telephone & Electronics Corporation Technical Series*
1960, 640 pages, $16.50



HERE IS the completely revised edition of the previous "Materials Technology for Electron Tubes," long known as the standard work on the subject in English. The text has been rewritten and reorganized on the basis of replies to a questionnaire submitted to a large number of competent users of the first edition. As a result, the text has been brought thoroughly up-to-date. The book covers all the material components of electron tubes and the methods of uniting them, such as joining of metals by brazing, glass-to-metal sealing, and ceramic-to-metal sealing. Chapters dealing with specific materials contain extensive tabulations of physical characteristics, chemical reactions with various reagents, and processes used in application.

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5 ACRYLIC RESINS

by MILTON B. HORN, *Group Leader, Acrylic R & D, Catalin Corp. of America*
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DESCRIBES the four types of acrylics in respect to their manufacture, fabrication and applications. These types include cast products, molding compounds, emulsion and solution compounds, and this is the first coverage of all types in one book. The author explains raw materials and manufacture of these polymers sufficient to an understanding of the problems involved in fabrication and application. Then he covers the current and future developments in terms of potential use in a great variety of products. All material presented in the book is available in the literature.

6 POLYESTER RESINS

by JOHN R. LAWRENCE, *Project Coordinator—Glidpol Resin, The Glidden Company*
1960, 256 pages, $5.75

HERE IS a comprehensive presentation of the unsaturated polyester resin industry. It covers all aspects from historic background, chemistry, curing mechanisms and manufacturing to techniques used in processing the resins for use in reinforced plastics, casting and coating applications. Particular emphasis is given to formulating resins for special properties such as weathering and flame resistance. The chapter on coating applications is the most complete coverage ever published on this relatively new use for polyester resins.

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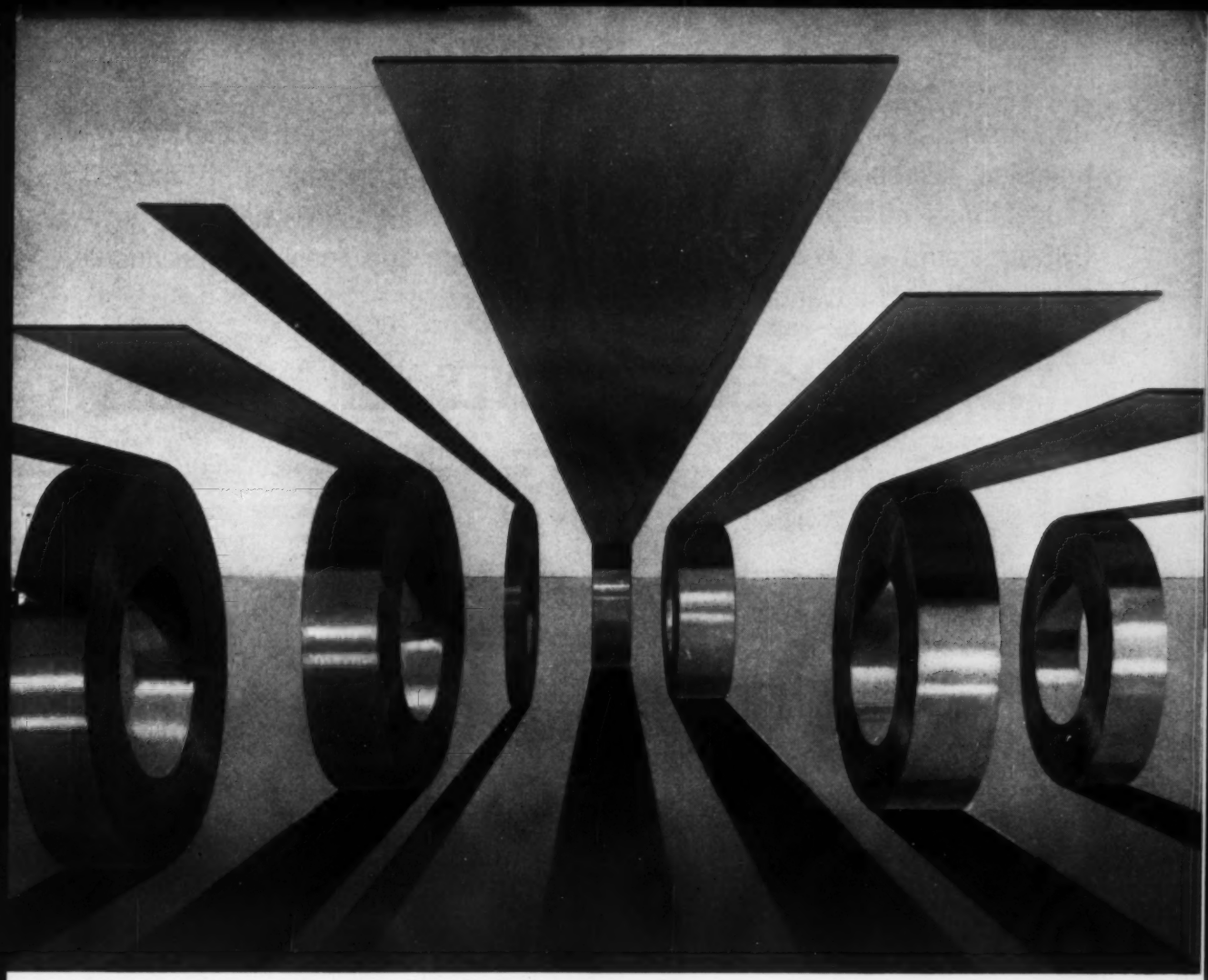

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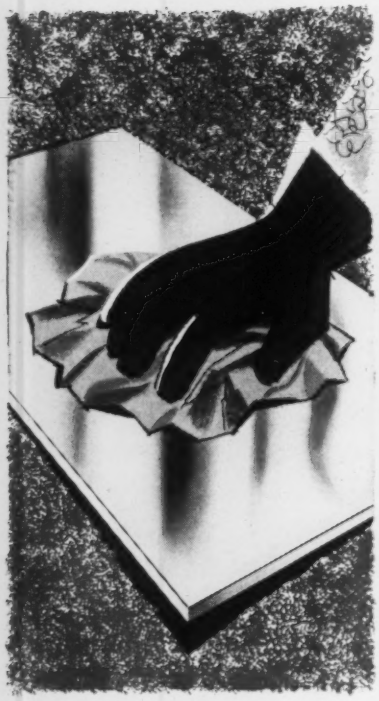

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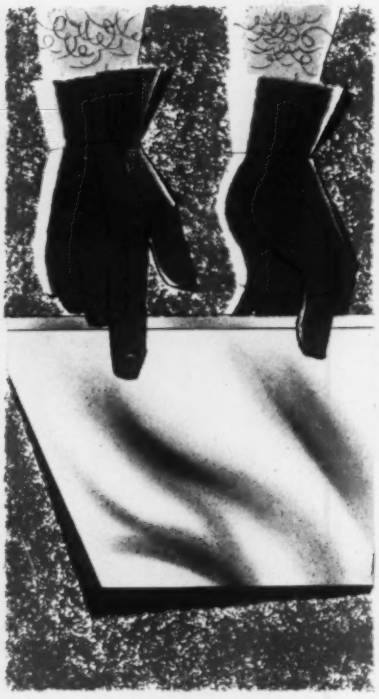

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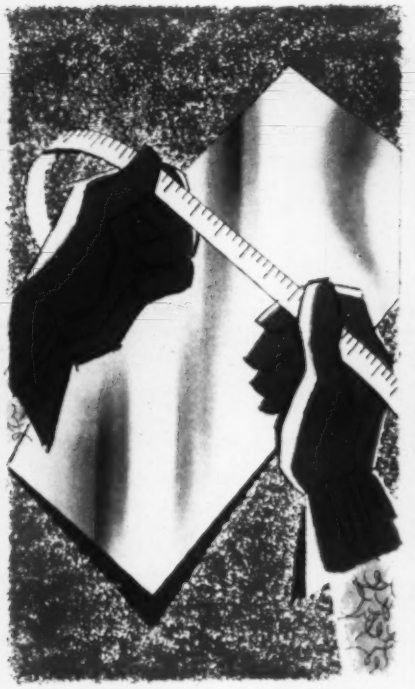

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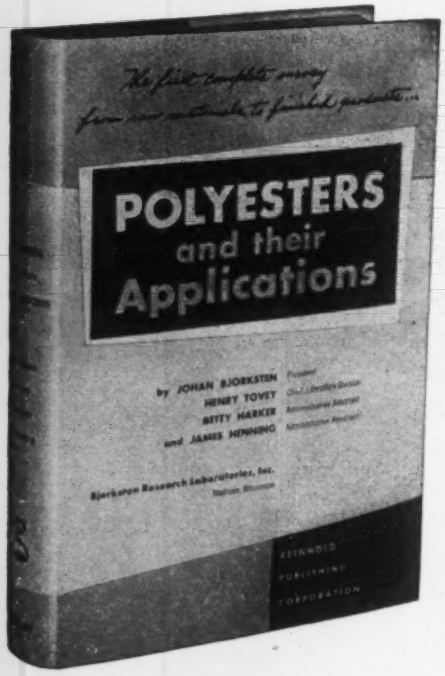
POLYESTERS

and their Applications



1956, 626 pages, $10.00

by JOHAN BJORKSTEN
President

HENRY TOVEY
Chief, Literature Division

BETTY HARKER
Administrative Assistant

and JAMES HENNING
Administrative Assistant

all of Bjorksten Research Laboratories, Inc.
Madison, Wisconsin

This book is the first comprehensive survey of the entire polyester field from raw materials to fabricated product. The text and annotated bibliography of over 3300 references cover most phases of the production and use of polyesters. You will find here a storehouse of valuable information and a tremendous time-saver in seeking background information. Now you can quickly locate any patents or literature bearing on some particular phase of the polyester field. Included are not only the unsaturated polyesters used in molding, casting, coating, impregnating, and laminating, but also the saturated polyesters used in production of fibers, films, elastomers, and foamed plastics.

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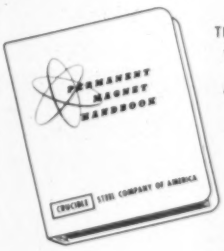

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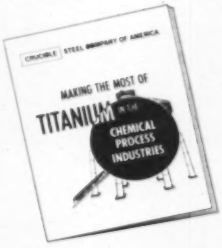

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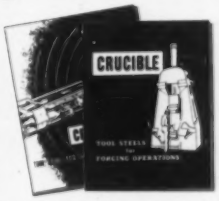

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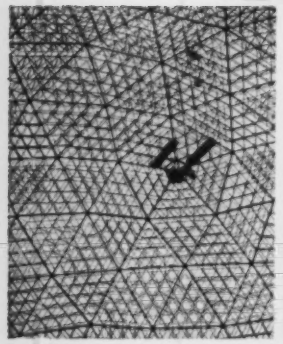

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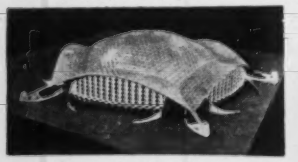

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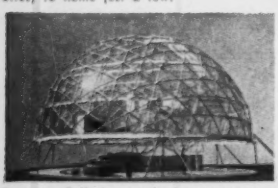

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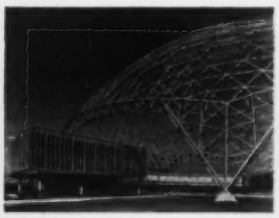

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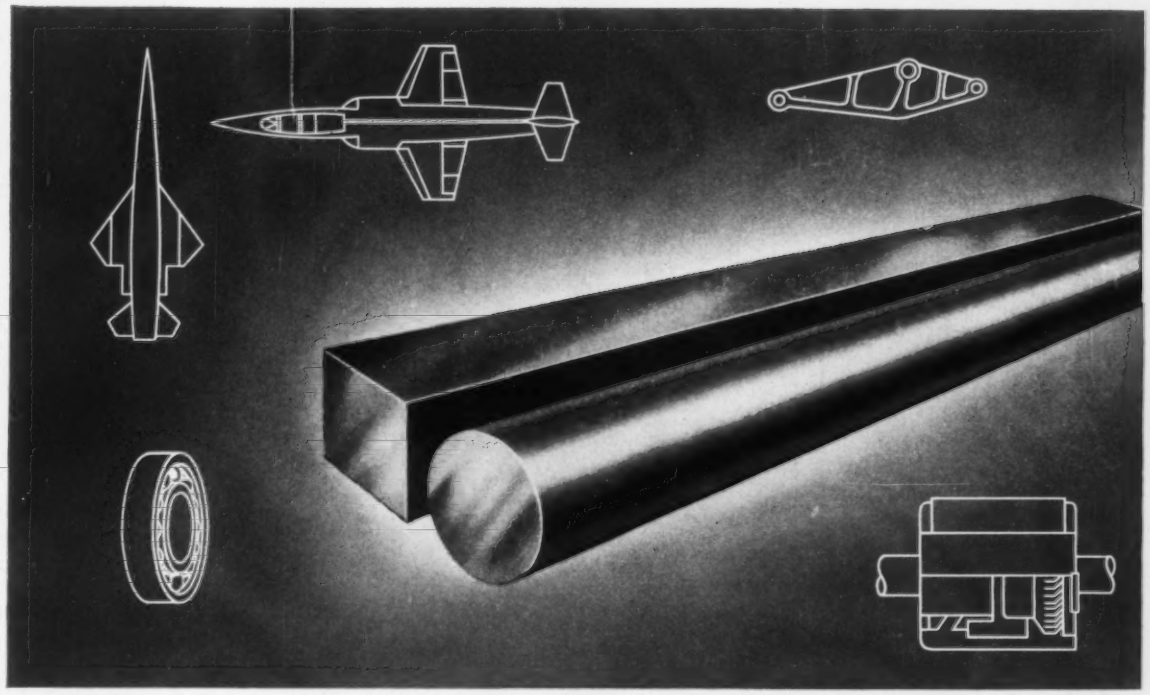

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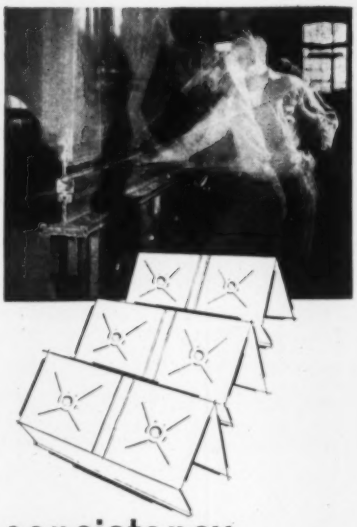

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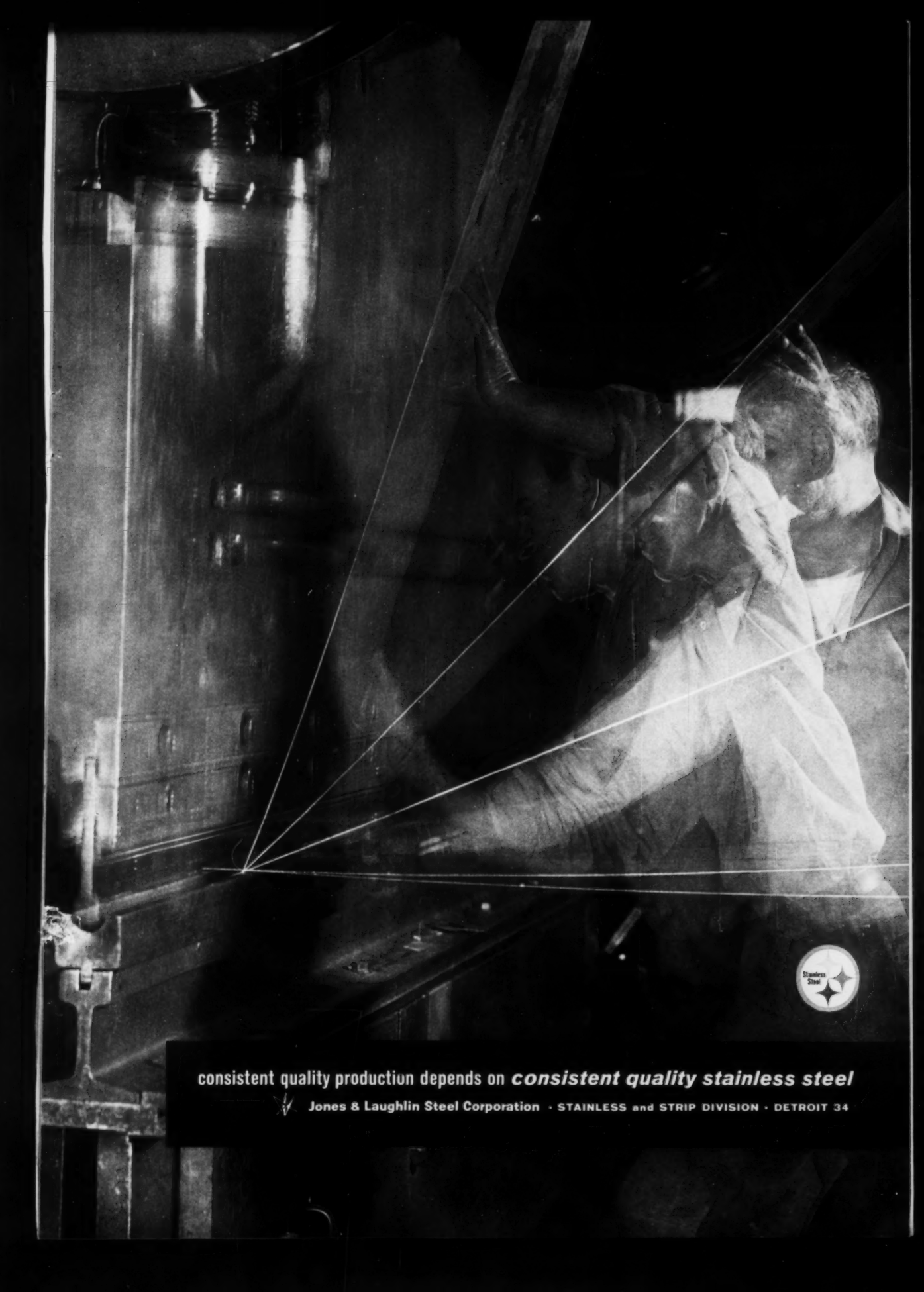
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Molybdenum Metal. Climax Molybdenum Co., Div. of American Metal Chmax, Inc., 110 pp, illus. Applications, physical and mechanical properties, corrosion resistance, oxidation resistance and protection, fabrication of parts, methods of production, laboratory techniques, weight tables, references, and other data on molybdenum metal. **33**

High Strength Aluminum Casting Alloy. Federated Metals Div., American Smelting & Refining Co., 6 pp, illus. Physical and mechanical properties, specifications, composition and foundry characteristics of a high strength aluminum casting alloy that requires no heat treatment. **34**

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Alloys for Electronics. Wilbur B. Driver Co., 8 pp, illus., No. E102. Compositions, properties, resistance vs temperature curves, and other engineering data on alloys used for electron tubes, indirectly heated cathodes, plate materials, grid wire, and glass sealings alloys. **42**

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Cobalt-Chromium Superalloy. Kelsey-Hayes Co., Metals Div., 8 pp, illus. Chemical composition, physical constants, mechanical properties, isostress curves, heat treatment, finishing and available forms of a cobalt-chromium superalloy used in jet engines, missiles and electronic tubes. **53**

Uses of Tin. Malayan Tin Bureau, 20 pp, illus. Detailed descriptions of several uses of tin including tinplate, solder, bronze, babbitt, white metals, tinning, tubes, chemicals, etc. **54**

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Magnesium Wrought Products. A. R. Purdy Co., Inc., 4 pp. Dimensions for such magnesium wrought products as sheet, plate, rod, bar, round and square tubing, structural shapes and welding rod. **57**

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Tantalum-Tungsten Alloy. Stauffer-Temescal Co. Information on an electron-beam melted tantalum alloy containing 10% tungsten. Properties, fabrication data and typical applications. **62**

Germanium Ingots, Crystals. Sylvania Electric Products Inc., Chemical & Metallurgical Div., 4 pp, illus. Discusses purity, forms, types, uses and physical characteristics of germanium ingots and crystals. **63**

Corrosion Resistant Alloy. Haynes Stellite Co., Div. of Union Carbide Corp., 16 pp, illus. Corrosion resistance, chemical composition, physical properties, hardness, formability, impact strength and short-time tensile strength for a nickel-base alloy called Hastelloy alloy C. **64**

Columbium-Base Alloys. Union Carbide Metals Co., Div. of Union Carbide Corp., 6 pp, illus. Chemical compositions, and comparative data on strength and oxidation resistance of columbium-base alloys. **65**

Tantalum. Wah Chang Corp., 2 pp. Fabrication data, uses, and physical, mechanical and chemical properties of tantalum. **66**

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Nonferrous Metals

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Aluminum and Its Alloys—Wrought

Type →	EC	1100	3003	3004
COMPOSITION, %	Al 99.45 min	Al 99.0 min	Mn 1.0–1.5	Mn 1.0–1.5, Mg 0.8–1.3
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.098	0.098	0.099	0.098
Melting Temp Range, F	1195–1215	1190–1215	1190–1210	1165–1205
Ther Cond (77 F, ann.), Btu/hr/sq ft/°F/ft	135	128	111	93.8
Coef of Ther Exp (68 to 212 F), per °F	13.2×10^{-6}	13.1×10^{-6}	12.9×10^{-6}	12.9×10^{-6}
Spec Heat (212 F), Btu/lb/°F	—	0.22	0.22	0.22
Elec Res (68 F), microhm-cm				
Annealed	2.8	2.92	3.45	4.10
Hard (H18 or H38)	—	3.02	4.31	4.10
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	10×10^6	10×10^6	10×10^6	10×10^6
Ten Str (75 F), 1000 psi				
Annealed (O)	12	13	16	26
Half Hard	16 (H14)	18 (H14)	22 (H14)	35 (H34)
Hard	27 (H19)	24 (H18)	29 (H18)	41 (H38)
Yld Str (75 F), 1000 psi				
Annealed (O)	4	5	6	10
Half Hard	14 (H14)	17 (H14)	21 (H14)	29 (H34)
Hard	24 (H19)	22 (H18)	27 (H18)	36 (H38)
Elong (in 2 in., 75 F), %[a]				
Annealed (O)	23[d]	35, 45	30, 40	20, 25
Half Hard	—	9, 20 (H14)	8, 16 (H14)	9, 12 (H34)
Hard	1.5[d] (H19)	5, 15 (H18)	4, 10 (H18)	5, 6 (H38)
Hardness (Brinell)[b]				
Annealed (O)	—	23	28	45
Half Hard	—	32 (H14)	40 (H14)	63 (H34)
Hard	—	44 (H18)	55 (H18)	77 (H38)
Endurance Limit, 1000 psi				
Annealed (O)	—	5	7	14
Half Hard	—	7 (H14)	9 (H14)	15 (H34)
Hard	7 (H19)	9 (H18)	10 (H18)	16 (H38)
Shear Str, 1000 psi				
Annealed (O)	8	9	11	16
Half Hard	10 (H14)	11 (H14)	14 (H14)	18 (H34)
Hard	15 (H19)	13 (H18)	16 (H18)	21 (H38)
FABRICATING PROPERTIES				
Annealing Temp, F	650	650	775	650
Hot Working Temp Range, F	—	500–950	500–950	500–950
Machinability	Fair	Good	Good	Good
Relative Weldability[c]				
Torch	—	A	A	B
Inert Arc	A	A	A	A
Electrical Resistance	—	A	A	A
CORROSION RESISTANCE	High resistance to rural, industrial and marine atmospheres. Good resistance to most neutral or nearly neutral fresh waters; sea water; many foodstuffs; organic acids and anhydrides; alcohols; aldehydes; esters; ketones; oils, gasoline, greases, waxes, and other petroleum derivatives; ammonia and ammonium compounds; nitric acid above 82%; essential oils; amides; nitroparaffins; coal tar derivatives; hydrogen peroxide; and many neutral aqueous inorganic salt solutions			
AVAILABLE FORMS	Sheet, plate, wire, rod, bar			
	Foil, extrusions	Rivets, forgings, impact extrusions	Extruded shapes, tubing, forgings	Sheet, plate
USES	Electrical conductors	Cooking utensils, heat exchangers, pressure and storage tanks		Hydraulic tubing for commercial vehicles, storage tanks
		Chemical equipment, reflectors	Ductwork, truck panels, architectural applications, builders' hardware	

[a] Values given for 1/16-in. sheet and 1/2-in. bar, in that order. [b] 500-kg load, 10-mm ball.
[c] Letter A indicates most favorable, B less favorable, etc. Values relative to aluminum alloys only.
[d] Elongation (in 10 in.) for wire.

Aluminum and Its Alloys—Wrought

Type →	2011	2014[a, b]	2017	2024[c]
COMPOSITION, %	Cu 5.0–6.0, Pb 0.2–0.6, Bi 0.2–0.6	Cu 3.9–5.0, Si 0.5–1.2, Mn 0.4–1.2, Mg 0.2–0.8	Cu 3.5–4.5, Mn 0.4–1.0, Mg 0.2–0.8	Cu 3.8–4.9, Mn 0.3–0.9, Mg 1.2–1.8
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.102	0.101	0.101	0.100
Melting Temp Range, F	995–1190	950–1180	955–1185	935–1180
Ther Cond (77 F, annealed), Btu/hr/sq ft/°F/ft	81.7	111.0	99.4	111.0
Coef of Ther Exp, per °F				
68 to 212 F	12.8×10^{-6}	12.5×10^{-6}	12.7×10^{-6}	12.6×10^{-6}
68 to 572 F	13.9×10^{-6}	13.6×10^{-6}	13.9×10^{-6}	13.7×10^{-6}
Spec Heat, Btu/lb/°F	0.23	0.22	0.22	0.22
Elec Res (68 F), microhm-cm	4.31 (T3)	3.45 (O), 4.31 (T6)	3.83 (O), 5.75 (T4)	3.45 (O), 5.75 (T4)
MECHANICAL PROPERTIES[d]				
Mod of Elast in Tension, psi	10.2×10^6	10.6×10^6	10.5×10^6	10.6×10^6
Ten Str, 1000 psi				
Annealed (O)	—	27	26	27
Heat Treated	55 (T3), 59 (T8)	62 (T4), 70 (T6)	62 (T4)	70 (T3)
Yld Str (0.2% offset), 1000 psi				
Annealed (O)	—	14	10	11
Heat Treated	43 (T3), 45 (T8)	42 (T4), 60 (T6)	40 (T4)	50 (T3)
Elong (in 2 in.), %				
Annealed (O)	—	18	22	20[f]
Heat Treated	15 (T3), 12 (T8)	20 (T4), 13 (T6)	22 (T4)	18 (T3)[f]
Hardness (Brinell)				
Annealed (O)	—	45	45	47
Heat Treated	95 (T3), 100 (T8)	105 (T4), 135 (T6)	105 (T4)	120 (T3)
Endurance Limit, 1000 psi				
Annealed (O)		13	13	13
Heat Treated	18 (T3), 18 (T8)	20 (T4), 18 (T6)	18 (T4)	20 (T3)
Shear Str, 1000 psi				
Annealed (O)	—	18	18	18
Heat Treated	32 (T3), 35 (T8)	38 (T4), 42 (T6)	38 (T4)	41 (T3)
FABRICATING PROPERTIES				
Annealing Temp, F	775	775	775	775
Solution Temp, F	950	940	940	920
Aging Temp, F	320	340	—	375
Machinability[e]	A (T3, T8)	A (T6)	A (T4)	A (T3)
Relative Weldability[e]				
Torch	D	D	D	D
Inert Arc	D	B	B	B
Electrical Resistance	D	B	A	B
CORROSION RESISTANCE	Compared to other aluminum alloys, this group has high resistance to rural atmospheres, fairly good resistance to industrial atmospheres, and poor resistance to marine atmospheres and sea water. More susceptible to corrosive attack than other groups of wrought aluminum alloys. Both degree and nature of the attack are greatly influenced by thermal treatment. Clad sheet alloys generally have high corrosion resistance			
AVAILABLE FORMS	Rod, hexagon bar, wire	Extruded shapes, rolled shapes, forgings, rod, bar	Rod, bar, wire	Sheet, plate, rod, bar, tubing, wire, rivets, extruded shapes
USES	Screw machine products	Heavy duty forgings, power shovel bails, airplane fittings, structural members	Screw machine products	Screw machine products

[a] 2014 available clad with 6053.
[b] Similar to 2014 is Hardclad 301. Core: 4.0-5.0 Cu, 0.75-1.2 Si, 0.70-1.0 Mn, 0.25-0.55 Mg. Claddings: 0.50-0.90 Si, 0.25-0.75 Mn, 0.80-1.2 Mg.
[c] 2024 available clad with aluminum of 99.3% min purity.
[d] Values given on ½-in. sheet and ½-in. bar, in that order.
[e] Letter A indicates most favorable, B less favorable, etc. Relative to aluminum alloys only.
[f] Elongation (in 10 in.) for wire.

continued on next page

Aluminum and Its Alloys—Wrought

Type →	5005	5050	5052	5056
COMPOSITION, %	Mg 0.8	Mg 1.0–1.8	Mg 2.2–2.8, Cr 0.15–0.35	Mn 0.05–0.20, Mg 4.7–5.6, Cr 0.05–0.20
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.097	0.097	0.097	0.095
Melting Temp Range, F	1160–1205	1160–1205	1100–1200	1055–1180
Ther Cond (77 F, ann.), Btu/hr/sq ft/°F/ft	111	111	79.2	67.4
Coef of Ther Exp, per °F				
68 to 212 F	13.3×10^{-6}	13.2×10^{-6}	13.2×10^{-6}	13.4×10^{-6}
68 to 572 F	—	14.2×10^{-6}	14.3×10^{-6}	14.5×10^{-6}
Spec Heat (212 F), Btu/lb/°F	0.23	0.22	0.22	0.22
Elec Res (68 F), microhm-cm				
Annealed	3.4	—	4.93	5.94
Hard (H18 or H38)	—	—	4.93	6.39
MECHANICAL PROPERTIES				
Mod of Elasticity in Tension, psi	10×10^6	10×10^6	10.2×10^6	10.3×10^6
Ten Str (75 F), 1000 psi				
Annealed (O)	18	21	28	42
Half Hard	23 (H14)	28 (H34)	38 (H34)	—
Hard	29 (H18)	32 (H38)	42 (H38)	60 (H38)
Yld Str (75 F), 1000 psi				
Annealed (O)	6	8	13	22
Half Hard	22 (H14)	24 (H34)	31 (H34)	—
Hard	28 (H18)	29 (H38)	37 (H38)	50 (H38)
Elong (in 2 in., 75 F), %[a]				
Annealed (O)	30, —	24	25, 30	—, 35
Half Hard	6, — (H14)	8 (H34)	10, 14 (H34)	—
Hard	4, — (H18)	6 (H38)	7, 8 (H38)	—, 15 (H38)
Hardness (Brinell)[b]				
Annealed (O)	28	36	47	65
Half Hard	41 (H14)	53 (H34)	68 (H34)	—
Hard	51 (H38)	63 (H38)	77 (H38)	105(H18),100(H38)
Endurance Limit, 1000 psi				
Annealed (O)	—	12	16	20
Half Hard	—	13 (H34)	18 (H34)	—
Hard	—	14 (H38)	20 (H38)	22 (H38)
Shear Str, 1000 psi				
Annealed (O)	11	15	18	26
Half Hard	14 (H14)	18 (H34)	21 (H34)	—
Hard	16 (H18)	20 (H38)	24 (H38)	32 (H38)
FABRICATING PROPERTIES				
Annealing Temp, F	650	650	650	650
Hot Working Temp Range, F	—	—	500–950	500–950
Machinability	Good	Good	Good	Good
Relative Weldability[c]				
Torch	—	B	B	C
Inert Arc	—	A	A	A
Electrical Resistance	—	A	A	B
CORROSION RESISTANCE	High resistance to rural, industrial and marine atmospheres. Good resistance to most neutral or nearly neutral fresh waters; sea water; many foodstuffs; organic acids and anhydrides; alcohols; aldehydes; esters; ketones; oils, gasoline, greases, waxes, and other petroleum derivatives; ammonia and ammonium compounds; nitric acid above 82%; essential oils; amides; nitroparaffins; coal tar derivatives; hydrogen peroxide; and many neutral aqueous inorganic salt solutions			
AVAILABLE FORMS	Foil, sheet, plate	Sheet, plate, drawn tube	Sheet, plate, wire, rod, bar, drawn tubing	Rod, wire
USES	Appliances, cooking utensils, architectural applications	Decorative refrigerator parts, coiled tubes, builders' hardware	Bus and truck bodies, aircraft tubing, milk crates, fan blades, kitchen cabinets	Cable sheathing, rivets for magnesium

[a] Values given for 1/16-in. sheet and 1/2-in. bar, in that order. [b] 500-kg load, 10-mm ball.
[c] Letter A indicates most favorable, B less favorable, etc. Values relative to aluminum alloys only.

Aluminum and Its Alloys—Wrought

Type →	5083	5086	5154	5456
COMPOSITION, %	Mg 4.0–4.9, Mn 0.5–1.0, Cr 0.25 max	Mg 3.5–4.5, Mn 0.2–0.7, Cr 0.25 max	Mg 3.5, Cr 0.25	Mg 4.7–5.5, Mn 0.5–1.0, Cr 0.05–0.20
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.096	0.096	0.096	0.096
Melting Temp Range, F	1065–1180	1084–1184	1100–1190	—
Ther Cond (77 F, ann.), Btu/hr/sq ft/°F/ft	68	73	73	—
Coef of Ther Exp (68–212 F), per °F	13.2×10^{-6}	13.2×10^{-6}	13.3×10^{-6}	13.3×10^{-6}
Spec Heat (212 F), Btu/lb/°F	0.23	0.23	0.23	0.23
Elec Res (68 F), microhm-cm				
Annealed	5.9	5.5	5.3	5.9
Hard	—	5.5	5.3	—
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	10.3×10^6	10.3×10^6	10.2×10^6	10.3×10^6
Ten Str (75 F), 1000 psi				
Annealed (O)	42	38	35	45
Half Hard	46 (H113)	47 (H34)	42 (H34)	51 (H321)
Hard	—	—	48 (H38)	—
Yld Str (75 F), 1000 psi				
Annealed	21	17	17	23
Half Hard	33 (H113)	37 (H34)	33 (H34)	37 (H321)
Hard	—	—	39 (H38)	—
Elong (in 2 in., 75 F), %[a]				
Annealed (O)	22, —	22, —	27, —	24, —
Half Hard	16 (H113), —	10 (H34), —	13 (H34), —	16 (H321), —
Hard	—	—	10 (H38), —	—
Hardness (Brinell)[b]				
Annealed (O)	73	B16[d]	58	75
Half Hard	—	B44[d]	78 (H34)	90 (H321)
Hard	—	—	87 (H38)	—
Endurance Limit, 1000 psi				
Annealed (O)	—	—	17	—
Half Hard	23 (H113)	16 (H34)	19 (H34)	—
Hard	—	—	21 (H38)	—
Shear Str, 1000 psi				
Annealed (O)	25	23	22	28
Half Hard	—	27 (H34)	24 (H34)	30 (H321)
Hard	—	—	28 (H38)	—
FABRICATING PROPERTIES				
Annealing Temp, F	650	650	650	—
Machinability	D	D	D	D
Relative Weldability[c]				
Torch	D	C	C	D
Inert Arc	A	A	A	A
Electrical Resistance	B	B	B	B
CORROSION RESISTANCE	High resistance to rural, industrial and marine atmospheres. Good resistance to most neutral or nearly neutral fresh waters; sea water; many foodstuffs; organic acids and anhydrides; alcohols; aldehydes; esters; ketones; oils, gasoline, greases, waxes, and other petroleum derivatives; ammonia and ammonium compounds; nitric acid above 82%; essential oils; amides; nitroparaffins; coal tar derivatives; hydrogen peroxide; and many neutral aqueous inorganic salt solutions			
AVAILABLE FORMS	Plate, extrusions, sheet, structural shapes, bar, rod	Sheet, plate, extrusions, structural shapes	Sheet, plate, welding wire, pipe, rod, bar	Sheet, plate, extrusions, rods, bar, structural shapes
USES	Unfired pressure vessels, marine superstructures, decks and hulls, auto frames, aircraft landing gears, TV structural towers, drilling rigs, welded assemblies	Transportation equipment, welded construction, unfired pressure vessels, guided missile containers	Unfired pressure vessels, welded construction, storage tanks, truck and marine applications	Deck housing, heavy duty structures, overhead cranes, gun mounts, pressure vessels, storage tanks

[a] Values given for ⅛-in. sheet and ½-in. bar in that order. [b] 500-kg load, 10-mm ball.
[c] Letter A indicates most favorable, B less favorable, etc. Values relative to aluminum alloys only.
[d] Rockwell hardness.

continued on next page

Aluminum and Its Alloys—Wrought

Type →	6061	6063	7075	7079
COMPOSITION, %	Mg 0.8–1.2, Si 0.4–0.8, Cr 0.15–0.35, Cu 0.15–0.40	Mg 0.45–0.9, Si 0.2–0.6	Zn 5.1–6.1, Mg 2.1–2.9, Cu 1.2–2.0, Cr 0.18–0.40	Zn 3.8–4.8, Mg 2.9–3.7, Cu 0.4–0.8, Mn 0.1–0.3, Cr 0.1–0.25
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.098	0.098	0.101	0.099
Melting Temp Range, F	1080–1200	1140–1205	890–1180	900–1180
Ther Cond (77 F), Btu/hr/sq ft/°F/ft	99	111	70 (T6)	70 (T6)
Coef of Ther Exp, per °F				
68–212 F	13.0×10^{-6}	13.0×10^{-6}	12.9×10^{-6}	13.1×10^{-6}
68–572 F	14.1×10^{-6}	14.2×10^{-6}	14.4×10^{-6}	14.2×10^{-6}
Specific Heat, Btu/lb/°F	0.23	—	0.23	—
Elec Res (68 F), microhm-cm	3.8 (O)	3.1 (T6)	5.7 (T6)	5.5 (T6)
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	10.0×10^6	10.0×10^6	10.4×10^6	10.3×10^6
Ten Str, 1000 psi				
Annealed (O)	18	13	33	—
Heat Treated	35 (T4), 45 (T6)	25 (T4), 35 (T6)	83 (T6)	78 (T6)
Yld Str (0.2% offset), 1000 psi				
Annealed (O)	8	7	15	—
Heat Treated	21 (T4), 40 (T6)	13 (T4), 31 (T6)	73 (T6)	68 (T6)
Elong (in 2 in.), %				
Annealed (O)	25	—	17	—
Heat Treated	22 (T4), 12 (T6)	22 (T4), 12 (T6)	11 (T6)	14 (T6)
Hardness (Brinell)				
Annealed (O)	30	25	60	—
Heat Treated	65 (T4), 95 (T6)	—, 73 (T6)	150 (T6)	145 (T6)
Endurance Limit, 1000 psi				
Annealed (O)	9	8	—	—
Heat Treated	14 (T4), 14 (T6)	—, 10 (T6)	23 (T6)	23 (T6)
Shear Str, 1000 psi				
Annealed (O)	12	10	22	—
Heat Treated	24 (T4), 30 (T6)	—, 22 (T6)	48 (T6)	45 (T6)
FABRICATING PROPERTIES				
Annealing Temp, F	775	775	775	—
Solution Temp, F	970	—	880	830
Aging Temp, F	340	350–450	250	240–250
Machinability[a]	B (T4, T6)	B (T4, T6)	A (T6)	A (T6)
Relative Weldability[a]				
Torch	A	A	D	D
Inert Arc	A	A	C	C
Elec Res	A	A	C	C
CORROSION RESISTANCE	Compared with other aluminum alloys, these alloys have high resistance to rural atmospheres, good resistance to industrial and marine atmospheres. Degree and nature of attack in other environments is greatly influenced by heat treatment. Clad alloys have corrosion resistance of the cladding alloy		Compared with other aluminum alloys, these alloys have good corrosion resistance to rural atmospheres but are attacked by industrial and marine atmospheres. In other environments, they are generally less corrosion resistant than other wrought aluminum alloys and are frequently clad. Clad alloys have corrosion resistance of the cladding alloy	
AVAILABLE FORMS	Sheet, plate, wire, rod, bar, pipe, tubing, rolled and extruded shapes forgings	Extruded shapes, tube, pipe	Sheet, plate, wire, rod, bar, extruded shapes, tube, pipe, forgings	Forgings, extrusions, sheet, plate
USES	Transportation equipment, heavy duty structures, marine uses, pipe, furniture	Pipe, railings, hardware, architectural uses	Structural parts for aircraft	

[a] Letter A indicates most favorable, B less favorable, etc. Relative to aluminum alloys only.

Aluminum and Its Alloys—Cast

Type →	195	B195	108	A108
COMPOSITION, %	Cu 4.5, Al bal	Cu 4.5, Si 2.5, Al bal	Cu 4.0, Si 3.0, Al bal	Cu 4.5, Si 5.5, Al bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.101	0.100	0.100	0.100
Solid. Temp Range, F	1195–910	1160–980	1160–970	1135–970
Ther Cond (as cast, 68 F), Btu/hr/sq ft/°F/ft	82.5	92.5	70	82
Coef of Ther Exp (68–212 F), per °F	12.7×10^{-6}	12.2×10^{-6}	12.2×10^{-6}	11.9×10^{-6}
Elec Cond (as cast), % IACS	36	42.5	31	37
MECHANICAL PROPERTIES				
Ten Str, 1000 psi				
As Cast	—	—	21	28
Sol'n Heat Treated	32	37	—	—
Sol'n Treated & Aged	36	40	—	—
Yld Str (0.2% offset), 1000 psi				
As Cast	—	—	14	16
Sol'n Heat Treated	16	19	—	—
Sol'n Treated & Aged	24	26	—	—
Elong (in 2 in.), %				
As Cast	—	—	2.5	2.0
Sol'n Heat Treated	8.5	9.0	—	—
Sol'n Treated & Aged	5.0	5.0	—	—
Hardness (Brinell)				
As Cast	—	—	55	70
Sol'n Heat Treated	60	75	—	—
Sol'n Treated & Aged	95	90	—	—
Endurance Limit, 1000 psi				
Sol'n Heat Treated	7	9.5	11	—
Sol'n Treated & Aged	8	10.0	—	—
Compr Yld Str, 1000 psi				
As Cast	—	—	14	16
Sol'n Heat Treated	17	20	—	—
Sol'n Treated & Aged	25	26	—	—
Shear Str, 1000 psi				
As Cast	—	—	17	25
Sol'n Heat Treated	26	30	—	—
Sol'n Treated & Aged	30	32	—	—
THERMAL TREATMENT				
Annealing Temp, F	650	650	650	650
Solution Temp, F	960	950	960	940
Aging Temp, F	310	310	310	310
FABRICATING PROPERTIES				
Machinability*	AB	AB	C	C
Weldability*				
Gas	C	C	B	A
Arc	B	B	D	A
Resistance	B	B	B	A
CORROSION RESISTANCE	Good corrosion resistance; alloys containing silicon are superior. In general: Resistant to nitric, chromic and most organic acids; attacked by hydrochloric and sulfuric acids. Resistant to ammonium hydroxide; attacked by sodium, potassium and calcium hydroxides. Resistant to many salts, but attacked by salts of heavy metals. Resistant to attack by industrial and marine atmospheres			
AVAILABLE FORMS	Sand castings	Permanent mold castings	Sand castings	Permanent mold castings
USES	Crankcases, bus wheels, housings, spring hangers, fittings	Aircraft fittings, fuel pump bodies, gear housings, seat frames	Manifolds, valve bodies, pressure-tight parts	Parts requiring pressure tightness

* General purpose castings. * A = excellent, AB = very good, B = good, C = fair, D = poor.

continued on next page

Aluminum and Its Alloys—Cast

Type →	214	220	43	356
COMPOSITION, %	Mg 4.0, Al bal	Mg 4.0, Al bal	Si 5.25, Al bal	Si 7.0, Mg 0.35, Al bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.095	0.093	0.097	0.097
Solid. Temp Range, F	1185–1075	1150–840	1170–1065	1130–1035
Ther Cond (as cast, 68F), Btu/hr/sq ft/°F/ft	80	51	85	92
Coef of Ther Exp (68–212 F), per °F	13.3 x 10^{-6}	13.6 x 10^{-6}	12.2 x 10^{-6}	11.9 x 10^{-6}
Elec Cond (as cast), % IACS	35	21	38	41
MECHANICAL PROPERTIES[f]				
Ten Str, 1000 psi				
As Cast	25	—	19	—
Sol'n Heat Treated	—	46	—	—
Aged[e]	—	—	—	25, 40
Yld Str (0.2% offset), 1000 psi				
As Cast	12	—	8	—
Sol'n Heat Treated	—	25	—	—
Aged[e]	—	—	—	20, 27
Elong (in 2 in.), %				
As Cast	9.0	—	8	—
Sol'n Heat Treated	—	14	—	—
Aged[e]	—	—	—	2.0, 5.0
Hardness (Brinell)				
As Cast	50	—	40	—
Sol'n Heat Treated	—	75	—	—
Aged[e]	—	—	—	60, 90
Endurance Limit, 1000 psi				
As Cast	7	—	8	—
Sol'n Heat Treated	—	8	—	7.5, 13
Compr Yld Str, 1000 psi				
As Cast	12	—	9	—
Sol'n Heat Treated	—	26	—	—
Aged[e]	—	—	—	21, 27
Shear Str, 1000 psi				
As Cast	20	—	14	—
Sol'n Heat Treated	—	33	—	20, 32
THERMAL TREATMENT				
Annealing Temp, F	650	650	650	650
Solution Temp, F	—	810	—	1000
Aging Temp, F	—	—	—	310
FABRICATING PROPERTIES				
Machinability[d]	A	A	C	A
Weldability[d, f]				
Gas	B	D	A, —	A, A
Arc	A	C	A, —	A, A
Resistance	B	B	A, —	A, A
CORROSION RESISTANCE	Very good corrosion resistance; alloys containing silicon are superior. In general: Resistant to nitric, chromic and most organic acids; attacked by hydrochloric and sulfuric acids. Resistant to ammonium hydroxide; attacked by sodium, potassium and calcium hydroxides. Resistant to many salts, but attacked by salts of heavy metals. Resistant to attack by industrial and marine atmospheres			
AVAILABLE FORMS	Sand castings	Sand castings	Sand and perm mold castings	Sand and perm mold castings
USES	Dairy and food handling equipment, cooking utensils, chemical fittings, hardware	Aircraft fittings, levers, brackets, parts requiring shock resistance	Sand—marine fittings, food handling equipment, pipe fittings. Permanent mold — refrigerator fittings, carburetor bodies, thin-section general purpose castings	Sand—automotive transmission cases, housings, aircraft fittings

[b] Corrosion resistant castings. [d] A = excellent, AB = very good, B = good, C = fair, D = poor.
[f] Where two values are given they refer to sand and permanent mold castings, respectively.
[e] First value obtained by artificial aging; second value by solution treating and aging.

Aluminum and Its Alloys—Cast

Type →	122	142	355	40-E
COMPOSITION, %	Cu 10.0, Mg 0.25, Al bal	Cu 4.0, Mg 1.5, Ni 2.0, Al bal	Cu 1.25, Si 5.0, Mg 0.5, Al bal	Zn 5.5, Mg 0.6, Cr 0.5, Ti 0.20, Al bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.107	0.102	0.098	0.102
Solid. Temp Range, F	1160–1005	1165–995	1160–1070	1140–1060
Ther Cond (as cast, 68 F), Btu/hr/sq ft/°F/ft	77	87	87	80
Coef of Ther Exp (68–212 F), per °F	12.2×10^{-6}	12.5×10^{-6}	12.4×10^{-6}	13.7×10^{-6}
Elec Cond (as cast), % IACS	33	38.5	39	25
MECHANICAL PROPERTIES				
Tensile Strength, 1000 psi				
Artificially Aged	37	40	30	35
Sol'n Treated & Aged	48	47	42	—
Yield Strength (0.2% offset), 1000 psi				
Artificially Aged	35	34	24	25
Sol'n Treated & Aged	36	42	27	—
Elongation (in 2 in.), %				
Artificially Aged	0.5	1.0	2.0	3.0
Sol'n Treated & Aged	0.5	0.5	4.0	—
Hardness (Brinell)				
Artificially Aged	115	105	75	60–75
Sol'n Treated & Aged	140	110	90	—
Endurance Limit, 1000 psi				
Artificially Aged	8.5	10.5	7	10
Sol'n Treated & Aged	9	9.5	10	—
Compressive Yield Strength, 1000 psi				
Artificially Aged	40	34	24	17
Sol'n Treated & Aged	36	44	27	—
Shear Strength, 1000 psi				
Artificially Aged	27	26	24	28
Sol'n Treated & Aged	30	31	34	—
THERMAL TREATMENT				
Annealing Temp, F	650	650	650	—
Solution Temp, F	950	960	980	—
Aging Temp, F	310	650	310	356
FABRICATING PROPERTIES				
Machinability[b]	AB	AB	B	A
Weldability[b,f]				
Gas	C, D	C, C	A, A	C
Arc	B, C	B, B	A, A	C
Resistance	B, B	B, B	A, A	C
CORROSION RESISTANCE	Good corrosion resistance; alloy 355 is superior. In general resistant to nitric, chromic and most organic acids; attacked by hydrochloric and sulfuric acids. Resistant to ammonium hydroxide; attacked by sodium, potassium and calcium hydroxides. Resistant to many salts, but attacked by salts of heavy metals. Resistant to attack by industrial and marine atmospheres			
AVAILABLE FORMS	Sand and permanent mold castings	Sand and permanent mold castings	Sand and permanent mold castings	Sand castings
USES	Sand—cylinder heads, bearing caps, bushings, tappet guides. Permanent mold—meter parts, automotive pistons, bushings, bearings	Sand—cylinder heads, diesel engine pistons	Sand—cylinder heads, water jackets, housings, printing press bed plates. Permanent mold—aircraft supercharger impellers, timing gears, meter parts, rotors	Stressed parts of aircraft, turret housings, air compressor pistons, instrument parts, machine parts

[c] High temperature resistant castings.
[b] A = excellent, AB = very good, B = good, C = fair, D = poor.
[f] The two values refer to sand and permanent mold castings, respectively.

continued on next page

Aluminum and Its Alloys—Cast

Type ➡	218	431	A13	380
COMPOSITION, %	Mg 8.0, Al bal	Si 5.25, Al bal	Si 12.0, Fe 1.3 max Al bal	Cu 3.5, Si 8.5 Fe 1.3 max, Al bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.093	0.097	0.096	0.097
Solid. Temp Range, F	1150–995	1175–1070	1085–1065	1100–1000
Ther Cond (as cast, 68 F), Btu/hr/sq ft/°F/ft	56	84	70	58
Coef of Ther Exp (68–212 F), per °F	13.3×10^{-6}	12.2×10^{-6}	11.4×10^{-6}	11.7×10^{-6}
Elec Cond (as cast), % IACS	24	38	35	25
MECHANICAL PROPERTIES				
Ten Str, 1000 psi	42	30	35	43
Yld Str (0.2% offset), 1000 psi	23	16	21	26
Elong (in 2 in.), %	7.0	9.0	3.5	2.0
Endurance Limit, 1000 psi	18	17	19	20
Compr Yld Str, 1000 psi	27	16	21	25
Shear Str, 1000 psi	27	19	25	28
FABRICATING PROPERTIES				
Machinability•	A	C	A	AB
Weldability•				
Gas	D	B	D	D
Arc	D	B	D	D
Resistance	D	C	D	D
CORROSION RESISTANCE	Good corrosion resistance; alloys containing silicon are superior. In general: Resistant to nitric, chromic and most organic acids; attacked by hydrochloric and sulfuric acids. Resistant to ammonium hydroxide; attacked by sodium, potassium and calcium hydroxides. Resistant to many salts, but attacked by salts of heavy metals. Resistant to attack by industrial and marine atmospheres			
AVAILABLE FORMS	Die castings	Die castings	Die castings	Die castings
USES	Aircraft fittings and brake shoes, marine fittings, hardware	General purpose castings	Dental equipment, outboard motor pistons, typewriter frames	General purpose castings

◂ Die castings.
• A = excellent, AB = very good, B = good, C = fair, D = poor.

Aluminum and Its Alloys—Cast

Type →	319	C355	A356	327
COMPOSITION, %	Cu 3.8, Si 6.25, Al bal	Cu 1.25, Si 5.0, Mg 0.5, Al bal	Si 7.0, Mg 0.4, Al bal	Cu 1.5, Si 7.8, Mg 0.4, Mn 0.4, Al bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.100	0.097	0.097	0.096
Solid. Temp Range, F	1120–950	1160–1070	1130–1075	1110–1055
Ther Cond (as cast, 68 F), Btu/hr/sq ft/°F/ft	66	82[b]	92[b]	65
Coef of Ther Exp (68–212 F), per °F	12.0×10^{-6}	12.4×10^{-6}	11.9×10^{-6}	11.9×10^{-6}
Elec Cond (as cast), % IACS	28	37[b]	41[b]	29
MECHANICAL PROPERTIES[a]				
Tensile Strength, 1000 psi				
As Cast	27, 34	—	—	—, —
Solution Treated and Aged	36, 40	46	41	36, 49
Yld Str (0.2% offset), 1000 psi				
As Cast	18, 19	—	—	—, —
Solution Treated and Aged	24, 27	34	30	20, 40
Elongation (in 2 in.), %				
As Cast	2.0, 2.5	—	—	—, —
Solution Treated and Aged	2.0, 3.0	6.0	10.0	2.0, 3.0
Hardness, Brinell				
As Cast	70, 85	—	—	—, —
Solution Treated and Aged	80, 95	100	90	81, 97
Fatigue Str (5×10^8 cycles), 1000 psi				
As Cast	10, —	—	—	—, —
Solution Treated and Aged	10, —	13.0	10	—, —
Compr Yld Str (0.2% offset), 1000 psi				
As Cast	18, 19	—	—	—, —
Solution Treated and Aged	24, 27	36	—	20, —
Shear Str, 1000 psi[b]	—	33	35	—
THERMAL TREATMENT				
Annealing Temp, F	650	650	650	650
Solution Temp, F	940	980	1000	—
Aging Temp, F	310	310	310	—
FABRICATING PROPERTIES				
Machinability	Good	Good	Good	Good
Weldability (torch and arc)	Good	Good	Good	Good
CORROSION RESISTANCE	Fair	Good	Good	Good
AVAILABLE FORMS	Sand and permanent mold castings	Permanent mold castings	Permanent mold castings	Sand and permanent mold castings
USES	Engine parts, automotive cylinder heads, piano plates	Aircraft, missile and other structural uses requiring good strength		

[a] Where two values are given, they refer to sand and permanent mold castings, respectively. All single values are for permanent mold castings.
[b] Solution treated and aged.

Cobalt and Cobalt-Base Superalloys

Type →	Cobalt[a]	S-816	V-36	HS-25, L-602
COMPOSITION, %	Co 99.9	C 0.38, Mn 1.32, Cr 19.88, Ni 20.65, Mo 3.76, W 4.20, Cb 4.13, Fe 3.38, Co bal	C 0.32, Mn 0.99, Cr 25.0, Ni 19.0, Mo 4.48, Cb 2.3, Fe 2.4, Co bal	C 0.05–0.15, Mn 1.0–2.0, Cr 19.0–21.0, Ni 9.0–11.0, W 14.0–16.0, Fe 3.0, Si 1.0, Co bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.32	0.31	0.30	0.33
Melting Temp, F	2723	2350–2450	2350–2450	2425–2570
Ther Cond (1300 F), Btu/hr/sq ft/°F/ft	—	13.0	—	13 0
Coef of Ther Exp (70–1800 F), per °F	6.8×10^{-6}	8.3×10^{-6}	9.1×10^{-6}	9.4×10^{-6}
Spec Ht (77–1300 F), Btu/lb/°F	—	0.12	—	0.09
Elec Res, microhm-cm	—	93 (Aged)	—	34.9
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi				
Room Temp	30×10^6	35×10^6	32×10^6	$34\ 2 \times 10^6$
1200 F	—	28.4×10^6	—	27.4×10^6
1500 F	—	26.2×10^6	—	26.3×10^6
Ten Str, 1000 psi				
Room Temp	34.4	140	146	146
1500 F	—	73	51	47 (1600 F)
1800 F	—	26	28	25
2000 F	—	13	—	14
Yld Str (0.2% offset), 1000 psi				
Room Temp	20–43	70	67	67
1500 F	—	40	38	35 (1600 F)
1800 F	—	—	27	25
2000 F	—	—	—	12
Elongation (in 2 in.), %				
Room Temp	0.4	35	55	64
1500 F	—	22	8	30 (1600 F)
1800 F	—	20	16	35
2000 F	—	24	—	26
Fatigue Str (10^8 cycles), 1000 psi				
1200 F	—	38	—	31
1800 F	—	—	—	13
Rupture Str (1500 F), 1000 psi				
10 Hr	—	28	29	30
100 Hr	—	24	23	22
1000 Hr	—	18	18	18
THERMAL TREATMENT				
Solution Temp, F	—	2150 (1 hr, w.q.)	2250–2275 (1 hr, w.q.)	2250 (a.c.)
Aging Temp, F	—	1400 (12 hr, a.c.)	1400 (16 hr, a.c.)	—
FABRICATING PROPERTIES				
Hot Working Temp, F	930–1100	2250–1800	2250–1800	2250–1850
Machinability	Possible	9[b]	—	12[b]
Weldability	—	Good	Good	Good
CORROSION RESISTANCE	Excellent	Excellent	Excellent	Excellent
AVAILABLE FORMS	Rondelles, powders	Sheet, bar, billets, wire	Sheet, bar, billets, forgings, wire	Plate, sheet, bar, wire, tubing
USES	Alloy additions to steel cutting tools, magnets, etc.; also a coloring agent drier and catalyst	High temperature applications requiring strength and corrosion resistance		

[a] All properties are of as-cast material. [b] Based on AISI B1112 steel = 100.

Cobalt-Base Superalloys

Type ➡	HS-21	HS-31, X-40	Nivco
COMPOSITION, %	C 0.20–0.30, Ni 1.75–3.75, Cr 25.5–29.0, Mo 5.0–6.0, Fe 2.0, Mn 1.0, Si 1.0, B 0.007, Co bal	C 0.45–0.55, Ni 9.5–11.5, Cr 24.5–26.5, Fe 2.0, Mn 1.0, Si 1.0, W 7.0–8.0, Co bal	C 0.02–0.05, Ni 21.5–23.5, Fe 1.0, Zr 0.90–1.20, Ti 1.55–1.95, Al 0.15–0.30, Mn 0.20–0.50, Si 0.10–0.25, Co bal
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.30	0.31	0.31
Melting Temp, F	2465	—	1600–1700
Ther Cond (1100 F), Btu/hr/sq ft/°F/ft	11.9	12.8	18.0
Coef of Ther Exp (70–1500 F), per °F	8.7×10^{-6}	9.2×10^{-6}	8.1×10^{-6}
Elec Res (70 F), microhm-cm	87.4	—	23.7
MECHANICAL PROPERTIES[a]			
Mod of Elast in Tension, 10^6 psi			
Room Temp	36, 29	—, 27	30
1200 F	—, 23	—, 24 (1350 F)	21
Ten Str, 1000 psi			
Room Temp	101, 125	108, 128	165
1000 F	74, 94	80, —	130
1200 F	71, 85	76, 76 (1350 F)	105
1600 F	55, 42	34 (1700 F), 49	—
Yld Str (0.2% offset), 1000 psi			
Room Temp	82, 110	76, 113	110
1000 F	39, 80	41, —	90
1200 F	—, 71	—, —	75
1600 F	—, 33	—, 36	—
Elongation (in 1 in.), %			
Room Temp	8.2, 1.7	9.0, 2.0	25
1000 F	19.1,[b] 1.3[b]	17.5, —	27
1200 F	16.0, 2.3[b]	12.0, —	20
1600 F	23.0, 19.3[b]	22 (1700 F), 14.3	—
Hardness (room temp), Rockwell	C30, C38	C34, C42[d]	C32–40
Impact Str (Izod), ft-lb			
Room Temp	10, 4[c]	6, 4[c]	31
1500 F	27, 20[c]	16, 9[c]	—
Fatigue Str (10^8 cycles), 1000 psi			
Room Temp	35–40, —	—, —	52
1200 F	—, —	56, —	49
Rupture Str (1200 F), 1000 psi			
10 Hr	70, —	61, —	66
100 Hr	52, 22 (1500 F)	56, 29 (1500 F)	54
1000 Hr	42, 14 (1500 F)	51, 24 (1500 F)	43
THERMAL TREATMENT			
Solution Temp, F	—	—	1700–1900
Aging Temp, F	1350 (50 hr)	1350 (50 hr)	1150–1350
AVAILABLE FORMS	Investment castings	Investment castings	Bars, billets, strip, sheet, plate, wire, forgings
USES	Where resistance to thermal shock is required, especially in jet engines	Turbine blades and wheels and other parts subject to high temperatures	Where high damping capacity at high temperature is required, e.g., compression blades, tool supports, precipitron wires, etc.

[a] For HS-21 and HS-31 (X-40), the two values correspond to as-cast and as-cast and aged (50 hr at 1350 F); values for Nivco are for bar stock.
[b] In 2 in. [c] Aged 24 hr at 1350 F. [d] Aged 50 hr at 1475 F.

Coppers—Wrought

Type →	Electrolytic Tough Pitch Copper	Phosphorus Deoxidized Copper	Beryllium Copper	Oxygen-Free Copper	Chromium Copper
COMPOSITION, %	Cu 99.90 min, O about 0.04	Cu 99.90 min, P 0.015–0.040	Be 1.90–2.15, Co 0.20–0.35, Cu bal	Cu 99.92	Cu 99.05, Cr 0.85, Si 0.10
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.321–0.323	0.323	0.296–0.298	0.323	0.321
Melting Temp Range, F	1949–1981	1981	1600–1800	1981	2147
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	226	196	100–110[a]	226	187[a]
Coef of Ther Exp (68–572 F), per °F	9.8×10^{-6}	9.8×10^{-6}	9.3×10^{-6}	9.8×10^{-6}	9.8×10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.092	0.092	0.10[b]	0.092	—
Elec Res (68 F, annealed), microhm-cm	1.71	2.03	4.82–5.82[a]	1.71	—
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	17×10^6	17×10^6	19×10^6	17×10^6	—
Ten Str, 1000 psi[c]					
Annealed	32, 35	32	60–80, 60–80[e]	32, 35	35, 63[j]
Hard	50, 55	50	165–185, 165–185[f]	50, 55	62, 70[j]
Yld Str, 1000 psi[c,d]					
Annealed	10	10	25–35, 20–30[e]	10	15, 45[j]
Hard	45	45	130–150, 150–170[f]	45	55, 60[j]
Elong (in 2 in.), %[c]					
Annealed	45, 35	45	35–50, 35–50[e]	45, 35	40, 25[j]
Hard	6, 1.5	10	3–12, 2–5[f]	6, 1.5	12, 20[j]
Hardness (Rockwell)					
Annealed	F40	F40	B50–65[e]	F40	F50, B65[j]
Hard	B50	B50	C36–41[f]	B50	B60, B84[j]
Shear Str, 1000 psi[c]					
Annealed	22, 24	22	50–60[e]	22, 24	—
Hard	28, 29	28	90–100[f]	28, 29	—
Endurance Limit (10^8 cycles), 1000 psi[c]					
Annealed	11	—	30–35, 12–20[e,g]	11	—
Hard	13	19	35–40, 120–140[f,g]	13	—
FABRICATING PROPERTIES					
Cold Workability	Excellent	Excellent	Good	Excellent	Good
Hot Workability	Excellent	Excellent	Excellent	Excellent	Good
Hot Working Temp, F	1400–1600	1400–1600	1050–1475	1400–1600	1650–1695
Annealing Temp, F	700–1200	700–1200	1400–1475	700–1200	—
Machinability Index[b]	20	20	20	20	20
Joining					
Soft Soldering	Excellent	Excellent	Excellent	Excellent	Excellent
Silver Alloy Brazing	Good	Excellent	Good	Excellent	Excellent
Oxyacetylene Welding	Poor	Good	Poor	Good	—
Carbon Arc Welding	Fair	Fair	Excellent	Good	—
Butt Resistance Welding	Good	Good	Excellent	Good	—
CORROSION RESISTANCE	Generally good resistance to industrial, rural and marine atmospheres; also gasolines, fuel oils and lacquers. Generally poor resistance to ammonia, ferric and ammonium compounds, and cyanides. Good resistance to weak acids and bases; some resistance to strong acids and bases				
AVAILABLE FORMS	Flat products, rod, wire, tube, pipe, shapes	Flat products, tube, pipe, rod, shapes	Flat products, rod, wire, tube, pipe, shapes		Flat products, wire, rod, shapes, simple forgings
USES	Architectural trim; automobile radiators; electrical contacts, conductors and switches; ball floats; rivets; chemical process equipment	Plumbing and gas lines; heat exchanger tubes; air, water, gasoline and oil lines; rotating bands	Instrument and valve springs, plunger guides, bushings, bearings, cams, diaphragms, bellows, electrical contacts, resistance welding electrodes	Bus bars and connectors, wave guides, copper-to-glass seals in electronic appliances	Resistance welding electrode tips and wheels, circuit breaker parts, cable connectors, parts for electronic devices

[a] Heat treated.
[b] 86–212 F.
[c] Where two values or ranges appear, second is for wire unless otherwise indicated.
[d] 0.5% extension under load except beryllium copper (0.2% offset).
[e] Solution annealed.
[f] Annealed and heat treated 2–3 hr at 600 F.
[g] Proportional limit.
[h] Based on free-cutting brass = 100.
[j] Heat treated rod: solution annealed ½ hr at 1830 F, quenched, precipitation heat treated 3 hr at 840 F.

Coppers and Plain Brasses—Wrought

Type →	Zirconium Copper	Sulfur Copper	Tellurium Copper	Gilding, 95%	Commercial Bronze, 90%
COMPOSITION, %	Zr 0.12, Cu bal	S 0.30, Cu bal	Te 0.50, Cu bal	Cu 95.0, Zn 5	Cu 90.0, Zn 10.0
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.323	0.323	0.323	0.320	0.318
Melting Temp Range, F	1976	1980	1980	1920–1950	1870–1910
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	—	216	209	135	109
Coef of Ther Exp (68–572 F), per °F	—	9.8×10^{-6}	9.8×10^{-6}	10.0×10^{-6}	10.2×10^{-6}
Spec Ht (68 F), Btu/lb/°F	—	0.09	0.09	0.09	0.09
Elec Res (68 F, annealed), microhm-cm	1.99	1.78	1.91	3.1	3.9
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	—	—	16×10^6	17×10^6	17×10^6
Ten Str, 1000 psi					
Annealed	—	34	—	34	37
Hard	56–80[b]	50[c]	48[c]	56	61
Yld Str (0.5% ext), 1000 psi					
Annealed	—	10	—	10	10
Hard	48–75[b]	48[c]	44[c]	50	54
Elong (in 2 in.), %					
Annealed	—	42	—	45	45
Hard	25–5[b]	12[c]	12[c]	5	5
Hardness (Rockwell)					
Annealed	—	—	—	F46	F53
Hard	B69–75[b]	B45[c]	B45[c]	B64	B70
Shear Str, 1000 psi					
Annealed	—	—	—	26	28
Hard	—	—	—	37	38
FABRICATING PROPERTIES					
Cold Workability	Excellent	Excellent	Good	Excellent	Excellent
Hot Workability	—	Excellent	Good	Good	Good
Hot Working Temp, F	—	1400–1600	1400–1550	1400–1600	1400–1600
Annealing Temp, F	—	800–1200	800–1200	800–1450	800–1450
Machinability Index[a]	20	90	90	20	20
Joining					
Soft Soldering	—	Excellent	Good	Excellent	Excellent
Silver Alloy Brazing	—	Excellent	Good	Excellent	Excellent
Oxyacetylene Welding	—	Fair	Fair	Good	Good
Carbon Arc Welding	—	Fair	Fair	Fair	Fair
Butt Resistance Welding	—	Good	Good	Good	Good
CORROSION RESISTANCE	Generally good resistance to industrial, rural and marine atmospheres; also gasolines, fuel oils and lacquers. Generally poor resistance to ammonia, ferric and ammonium compounds, and cyanides. Good resistance to weak acids and bases; some resistance to strong acids and bases				
AVAILABLE FORMS	Rod, wire	Rod	Rod	Rolled strip, wire	Rolled strip, sheet, wire, tube, plate, rod
USES	Commutator segments, slip rings, soldering iron tips, rectifier bases, resistance welding wheel electrodes, orifice for reaction motors	Electric and electronic parts, welding torch tips, soldering tips, screw machine parts requiring high conductivity	Torch tips, soldering iron tips, electrical connectors, screw machine products requiring high conductivity	Coins, bullet jackets, fuse caps, primers, jewelry, base for gold plate or vitreous enamel	Grillwork, cosmetic compacts, marine hardware, primer caps, costume jewelry, base for vitreous enamel

[a] Based on free-cutting brass = 100. [b] Range covers properties obtainable by varying amounts of cold work. [c] Half-hard.

continued on next page

Plain Brasses—Wrought

Type →	Red Brass, 85%	Low Brass, 80%	Cartridge Brass, 70%	Yellow Brass	Muntz Metal
COMPOSITION, %	Cu 85, Zn 15	Cu 80, Zn 20	Cu 70, Zn 30	Cu 65, Zn 35	Cu 60, Zn 40
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.316	0.313	0.308	0.306	0.303
Melting Temp Range, F	1810–1880	1770–1830	1680–1750	1660–1710	1650–1660
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	92	81	70	67	71
Coef of Ther Exp (68–572 F), per °F	10.4×10^{-6}	10.6×10^{-6}	11.1×10^{-6}	11.3×10^{-6}	11.6×10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.09	0.09	0.09	0.09	0.09
Elec Res (68 F, annealed), microhm-cm	4.7	5.4	6.2	6.4	6.2
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	17×10^6	16×10^6	16×10^6	15×10^6	15×10^6
Ten Str, 1000 psi[c]					
Annealed	39, 41	42, 44	44, 48	46, 50	54
Hard	70, 88	74, 107	76	74, 110	—
Yld Str, 1000 psi[c,d]					
Annealed	10	12	11	14	21
Hard	57	59	63	60	—
Elong (in 2 in.), %[c]					
Annealed	48, 48	52, 55	66, 64	65, 60	45
Hard	5, 6	7, 5	8	8, 8	—
Hardness (Rockwell)					
Annealed	F56	F57	F54	F58	F80
Hard	B77	B82	B82	B80	—
Shear Str, 1000 psi[c]					
Annealed	31, 31	32, 32	—	32, 34	40
Hard	42, 48	43, 53	44	43, 55	—
Endur Limit (10^8 cycles), 1000 psi[c]					
Annealed	10.5	14	13	12	—
Hard	21, 29	22, 23	21	14	—
FABRICATING PROPERTIES					
Cold Workability	Excellent	Excellent	Excellent	Excellent	Fair
Hot Workability	Good	Fair	Fair	Poor	Excellent
Hot Working Temp, F	1450–1650	1500–1650	1350–1550	—	1150–1450
Annealing Temp, F	800–1350	800–1300	800–1400	800–1300	800–1100
Machinability Index[j]	30	30	30	30	40
Joining					
Soft Soldering	Excellent	Excellent	Excellent	Excellent	Excellent
Silver Alloy Brazing	Excellent	Excellent	Excellent	Excellent	Excellent
Oxyacetylene Welding	Good	Good	Good	Good	Good
Butt Resistance Welding	Good	Good	Good	Good	Good
CORROSION RESISTANCE	Generally good resistance to industrial, rural and marine atmospheres; also gasolines, fuel oils and lacquers. Generally poor resistance to ammonia, ferric and ammonium compounds, and cyanides				
	Good res to weak acids and bases; some res to strong acids and bases. Highly res to dezincification or stress-corrosion cracking	Susceptible to dezincification and stress corrosion cracking			
		Good res to weak bases; some res to strong bases and weak acids; poor res to strong acids	Some resistance to weak acids and bases; poor resistance to strong acids and bases. Good resistance to sulfides. Poor resistance to soft and high salinity water		
AVAILABLE FORMS	Rolled strip, sheet, wire, tube, pipe	Wire, rolled strip and flat wire	Rolled strip and bar, flat wire, sheet, rod, wire, tube	Rolled strip and flat wire, drawn flat wire, sheet, plate, rod, wire	Rolled strip and bar, sheet, plate, rod, tube
USES	Weatherstrip, electrical sockets, fasteners, heat exchanger tubes, flexible hose, plumbing, jewelry	Ornamental metal work, battery caps, musical instruments, clock dials, pump lines	Automotive radiator cores and tanks, lamp fixtures, fasteners, springs, ammunition components	Grillwork, reflectors, lamp fixtures, fasteners, stencils, plumbing accessories, springs	Architectural trim, large nuts and bolts, condenser plates, hot forgings, valve stems

[c]Where two values appear, second is for wire. [d]0.5% extension under load. [j]Based on free-cutting brass = 100.

Tin and Aluminum Brasses—Wrought

Type →	Admiralty	Naval Brass	Leaded Naval Brass	Manganese Bronze (A)	Aluminum Brass
COMPOSITION, %	Cu 71, Sn 1, Zn 28	Cu 60, Sn 0.75, Zn 39.25	Cu 60, Pb 1.75, Sn 0.75, Zn 37.5	Cu 58.5, Fe 1.4, Sn 1, Mn 0.1, Zn 39	Cu 76, Al 2, Zn 22
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.308	0.304	0.305	0.302	0.301
Melting Temp Range, F	1650–1720	1630–1650	1630–1650	1590–1630	1710–1780
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	64	67	67	61	58
Coef of Ther Exp (68–572 F), per °F	11.2×10^{-6}	11.8×10^{-6}	11.8×10^{-6}	11.8×10^{-6}	10.3×10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.09	0.09	0.09	0.09	0.09
Elec Res (68 F, annealed), microhm-cm	6.9	6.6	6.6	7.2	7.5
MECHANICAL PROPERTIES[a]					
Mod of Elast in Tension, psi	16×10^6	15×10^6	15×10^6	15×10^6	16×10^6
Ten Str, 1000 psi					
Annealed[b]	53	57	57	65	60
Quarter Hard	—	69	69	77	—
Half Hard	—	75	75	84	—
Yld Str, 1000 psi[b]					
Annealed	22	25	25	30	27
Quarter Hard	—	46	46	45	—
Half Hard	—	53	53	60	—
Elong (in 2 in.), %					
Annealed	65	47	40	33	55
Quarter Hard	—	27	20	23	—
Half Hard	—	20	15	19	—
Hardness (Rockwell)					
Annealed	F75	B55	B55	B65	F77
Quarter Hard	—	B78	B78	B83	—
Half Hard	—	B82	B82	B90	—
Shear Str, 1000 psi					
Annealed	—	40	36	42	—
Quarter Hard	—	43	39	47	—
Half Hard	—	44	40	48	—
FABRICATING PROPERTIES					
Cold Workability	Excellent	Fair	Poor	Poor	Excellent
Hot Workability	Fair	Excellent	Good	Excellent	Fair
Annealing Temp, F	800–1100	800–1100	800–1100	800–1100	800–1100
Machinability Index[c]	30	30	70	30	30
Joining					
Soft Soldering	Excellent	Excellent	Excellent	Excellent	Fair
Silver Alloy Brazing	Excellent	Excellent	Good	Excellent	Good
Oxyacetylene Welding	Fair	Good	Fair	Good	Fair
Butt Resistance Welding	Good	Good	Fair	Good	Good
CORROSION RESISTANCE	Good resistance to industrial, rural and marine atmospheres; petroleum products, alcohols, dry gases and sea water. Fairly good resistance to weak bases. Resistance to some weak bases and weak organic acids, but generally poor resistance to most acids and strong bases. Poor resistance to solutions of cyanides and ammonium compounds. Resistant to dezincification (especially Admiralty and Aluminum Brasses)				
AVAILABLE FORMS	Plate, wire, tube	Rolled strip, rolled and drawn bar, plate, rod, tube, shapes	Drawn bar, rod, shapes	Rod, shapes	Tube
USES	Condenser, evaporator and heat exchanger tubes; condenser tube plates; distiller tubes; ferrules	Aircraft turnbuckle barrels, balls, bolts, marine hardware, nuts, propeller shafts, rivets, valve stems, condenser plates, welding rods	Marine hardware, screw machine products, valve stems	Clutch disks, pump rods, shafting, balls, valve stems and bodies, welding rods	Condenser, evaporator and heat exchanger tubes, distiller tubes, ferrules

[a] Mechanical properties are based on 1-in. dia. Values for Admiralty and Aluminum Brasses apply to tube; other values apply to rod.
[b] 0.5% extension under load. [c] Based on free-cutting brass = 100.

Leaded Brasses—Wrought

Type →	Leaded Commercial Bronze	Low-Leaded Brass	Medium-Leaded Brass	High-Leaded Brass	Extra-High-Leaded Brass
COMPOSITION, %	Cu 89.0, Pb 1.75, Zn 9.25	Cu 65.0, Pb 0.5, Zn 34.5	Cu 65.0, Pb 1.0, Zn 34.0	Cu 65.0, Pb 2.0, Zn 33.0	Cu 63.0, Pb 2.5, Zn 34.5
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.319	0.306	0.306	0.306	0.307
Melting Temp Range, F	1850–1900	1650–1700	1630–1700	1630–1670	1630–1660
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	104	67	67	67	67
Coef of Ther Exp (68–572 F), per °F	10.2×10^{-6}	11.3×10^{-6}	11.3×10^{-6}	11.3×10^{-6}	11.4×10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.09	0.09	0.09	0.09	0.09
Elec Res (68 F, annealed), microhm-cm	4.1	6.6	6.6	6.6	6.6
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	17×10^6	15×10^6	15×10^6	15×10^6	14×10^6
Ten Str, 1000 psi					
Annealed	—	51	51	49	49
Hard	55[b]	74	74	74	74
Yld Str (0.5% ext), 1000 psi					
Annealed	—	19	19	17	17
Hard	50[b]	60	60	60	60
Elong (in 2 in.), %					
Annealed	—	55	53	52	50
Hard	12[b]	8	7	7	7
Hardness (Rockwell)					
Annealed	—	F72	F72	F68	F68
Hard	B61[b]	B80	B80	B80	B80
Shear Str, 1000 psi					
Annealed	—	34	34	34	—
Hard	31[b]	43	43	43	—
FABRICATING PROPERTIES					
Cold Workability	Good	Good	Good	Fair	Poor
Hot Workability	Poor	Poor	Poor	Poor	Fair
Hot Working Temp, F	—	—	—	—	1300–1450
Annealing Temp, F	800–1200	800–1300	800–1200	800–1100	800–1100
Machinability Index[a]	80	60	70	90	100
Joining					
Soft Soldering	Excellent	Excellent	Excellent	Excellent	Excellent
Silver Alloy Brazing	Good	Good	Good	Good	Good
Oxyacetylene Welding	Not Rec	Fair	Not Rec	Not Rec	Not Rec
Butt Resistance Welding	Good	Good	Good	Good	Good
CORROSION RESISTANCE	Excellent resistance to pure hydrocarbons, lacquers and freon; good resistance to industrial, marine and rural atmospheres, alcohols, fuel oils and dry carbon dioxide; fair resistance to sea water, crude oils, and moist carbon dioxide; attacked by ammonium hydroxide and hydrochloric and sulfuric acids				
AVAILABLE FORMS	Bar, rod	Strip, bar, plate[c]	Strip, bar, plate, rod, wire	Strip, bar, plate, rod[d]	Strip, bar, plate, rod
USES	Screws, screw machine parts, pickling crates	Butts, hinge brass, watch backs	Butts, gears, nuts, rivets, screws, dials, engravings, instrument plates	Clock plates, nuts, backs, gears, wheels	

[a] Based on free-cutting brass = 100. [b] Half-hard.
[c] Low-leaded brass tube is also available which has approximately the same properties and is used for plumbing accessories and pumps.
[d] High-leaded brass tube is also available with approximately the same properties and is used for general purpose screw machine parts.

Leaded Brasses—Wrought

Type →	Free-Cutting Brass	Leaded Muntz Metal	Free-Cutting Muntz Metal	Forging Brass	Architectural Bronze
COMPOSITION, %	Cu 61.5, Pb 3.0, Zn 35.5	Cu 60.0, Pb 0.6, Zn 39.4	Cu 60.0, Pb 1.0, Zn 39.0	Cu 59.0, Pb 2.0, Zn 39.0	Cu 57.0, Pb 3.0, Zn 40.0
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.307	0.304	0.304	0.305	0.306
Melting Temp Range, F	1630–1650	1630–1650	1630–1650	1620–1640	1610–1630
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	67	71	69	69	71
Coef of Ther Exp (68–572 F), per °F	11.4×10^{-6}	11.6×10^{-6}	11.6×10^{-6}	11.5×10^{-6}	11.6×10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.09	0.09	0.09	0.09	0.09
Elec Res (68 F, annealed), microhm-cm	6.6	6.2	6.4	6.4	6.2
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	14×10^6	15×10^6	15×10^6	15×10^6	14×10^6
Ten Str, 1000 psi					
Annealed	49	54[c]	54	52[d]	60[d]
Hard	68[b]	—	80	—	—
Yld Str (0.5% ext), 1000 psi					
Annealed	18	20[c]	20	20[d]	20[d]
Hard	52[b]	—	60	—	—
Elong (in 2 in.), %					
Annealed	53	45[c]	40	45[d]	30[d]
Hard	18[b]	—	6	—	—
Hardness (Rockwell)					
Annealed	F68	F80[c]	F80	F78[d]	B65[d]
Hard	B80[b]	—	B85	—	—
Shear Str, 1000 psi					
Annealed	30	40[c]	—	—	35[d]
Hard	38[b]	—	—	—	—
FABRICATING PROPERTIES					
Cold Workability	Poor	Fair	Fair	Poor	Poor
Hot Workability	Fair	Excellent	Excellent	Excellent	Excellent
Hot Working Temp, F	1300–1450	1150–1450	1150–1450	1200–1500	1150–1350
Annealing Temp, F	800–1100	800–1100	800–1100	800–1100	800–1100
Machinability Index[a]	100	60	70	80	90
Joining					
Soft Soldering	Excellent	Excellent	Excellent	Excellent	Excellent
Silver Alloy Brazing	Good	Good	Good	Good	Good
Oxyacetylene Welding	Not Rec	Fair	Not Rec	Not Rec	Not Rec
Butt Resistance Welding	Good	Good	Good	Good	Good
CORROSION RESISTANCE	Excellent resistance to pure hydrocarbons, fluorinated hydrocarbon refrigerants and lacquers; good resistance to industrial, marine and rural atmospheres, alcohols, fuel oils and dry carbon dioxide; fair resistance to sea water, crude oils, and moist carbon dioxide; attacked by ammonium hydroxide and hydrochloric and sulfuric acids				
AVAILABLE FORMS	Bar, rod, shapes	Plate	Tube	Rod, shapes	Rod, shapes
USES	Gears, pinions, high speed screw machine parts	Condenser tube plates	Automatic screw machine parts	Forgings and pressings of all kinds	Architectural extrusions, store fronts, trim, hinges, lock bodies, forgings

[a] Based on free-cutting brass = 100. [b] Half-hard. [c] As hot rolled. [d] As extruded.

Phosphor Bronzes—Wrought

Type →	Phosphor Bronze, 5% (Grade A)	Phosphor Bronze, 8% (Grade C)	Phosphor Bronze, 10% (Grade D)	Phosphor Bronze, 1.25% (Grade E)	Phosphor Bronze (Free-Cutting)
COMPOSITION, %	Cu 95, Sn 5	Cu 92, Sn 8	Cu 90, Sn 10	Cu 98.75, Sn 1.25, P trace	Cu 88, Pb 4, Zn 4, Sn 4
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.320	0.318	0.317	0.321	0.321
Melting Temp Range, F	1750–1920	1620–1880	1550–1830	1900–1970	1700–1830
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	40	36	29	120	50
Coef of Ther Exp (68–572 F), per °F	9.9×10^{-6}	10.1×10^{-6}	10.2×10^{-6}	9.9×10^{-6}	9.6×10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.09	0.09	0.09	0.09	0.09
Elec Res (68 F, annealed), microhm-cm	9.6	13	16	3.6	9.1
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	16×10^6	16×10^6	16×10^6	17×10^6	15×10^6
Ten Str, 1000 psi[a]					
Annealed	47, 50	55, 60	66, 66	40, —	44, —
Half Hard	68, 85	76, 105	83, 118	55, —	58, —
Hard	81, 110	93, 130	100, 147	65, 76	—
Spring	100, 140	112, —	122, —	75, —	—
Extra Spring	107, —	120, —	128, —	—, —	—
Yld Str, 1000 psi[b]					
Annealed	19, 20	24	28	14	19
Half Hard	55, 80	55	—	—	40
Hard	75	72	—	50	—
Elong (in 2 in.), %					
Annealed	64, 58	70, 65	68	48	50
Half Hard	28, 8	32	32	16	24
Hard	10	10	13	8	—
Spring	4	3	4	4	—
Extra Spring	3	2	3	—	—
Hardness (Rockwell)					
Annealed	B26	F75	B55	—	F65
Half Hard	B78	B84	B92	B64	B68
Hard	B87	B93	B97	B75	—
Spring	B95	B98	B101	B79	—
Extra Spring	B97	B100	B103	—	—
FABRICATING PROPERTIES					
Cold Workability	Excellent	Good	Good	Excellent	Good
Hot Workability	Poor	Poor	Poor	Good (1450–1600 F)	—
Annealing Temp, F	900–1250	900–1250	900–1250	900–1200	900–1250
Machinability Index[c]	20	20	20	20	80
Joining					
Soft Soldering	Excellent	Excellent	Excellent	Excellent	Excellent
Silver Alloy Brazing	Excellent	Excellent	Good	Excellent	Excellent
Oxyacetylene Welding	Fair	Fair	Good	Good	Not rec
Butt Resistance Welding	Excellent	Excellent	Excellent	Excellent	Good
CORROSION RESISTANCE	Generally good resistance to atmosphere, water and salt water, and salt solutions. Some resistance to alkaline solutions and inorganic acids. Poor resistance to organic acids, cyanides, and ferric and ammonium compounds				
AVAILABLE FORMS	Rolled strip, rolled flat wire, rod, wire, tube	Rolled strip, rod, wire		Rolled strip, wire	Rolled strip, rod, shapes
USES	Bridge bearing plates, chemical hardware, perforated sheets, textile machinery, welding rods, beater bars, bellows, clutch disks, cotter pins, diaphragms, fuse clips, fasteners, lock washers, sleeve bushings, springs, switch parts, truss wire, wire brushes		Heavy bars and plates for severe compression, good wear and corrosion resistance. Bridge and expansion plates	Electrical contacts, flexible hose, pole-line hardware	Bearings, bushings, gears, pinions, shafts, thrust washers, valve parts

[a] Two values are for flat products and wire, respectively. [b] 0.5% extension under load. [c] Based on free-cutting brass = 100.

Silicon Bronzes

Type →	High Silicon Bronze (A)	Low Silicon Bronze (B)	Aluminum Silicon Bronze	Precipitation Hardenable Silicon Bronze [a]
COMPOSITION, %	Cu 94.8 min, Si 2.8–3.8, Mn 1.5 max, Zn 1.5 max, Fe 1.6 max, Ni 0.6 max	Cu 96.0 min, Si 0.8–2.0[e], Mn 0.7 max, Fe 0.8 max	Cu 89.0 min, Al 6.5–8.0, Si 1.5–3.0	Cu 97.5, Ni 1.9, Si 0.6
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.308	0.316	0.278	0.322
Melting Temp Range, F	1880–1780	1940–1890	1840[f]	1990[f]
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	20	31	26	—
Coef of Ther Exp (68–572 F), per °F	10.0×10^{-6}	9.9×10^{-6}	10.0×10^{-6}	9.8×10^{-6}
Specific Heat, Btu/lb/F	0.09	0.09	0.09	—
Elec Cond, % IACS	7	12	7	36[h]
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	15×10^6	17×10^6	16×10^6	18×10^6
Ten Str, 1000 psi				
Annealed Strip, Rod[b]	56–63	40[d]	85–90[d]	65[d]
Hardened Rod	92	70	90	100
Yield Strength (0.5% ext), 1000 psi				
Annealed Strip, Rod[b]	20–30	15[d]	44–60[d]	60[d]
Hardened Rod	55	55	50	88[d]
Elongation (in 2 in.), %				
Annealed Strip, Rod[b]	55–63	50[d]	20–30[d]	20[i]
Hardened Rod	22	15	40	22[d]
Hardness (Rockwell)				
Annealed Strip, Rod[b]	B35–66	F55–60	B74–90[d]	—
Hardened Rod	B90	B80	B92	B90[d]
Impact Strength (Izod, annealed strip, rod), ft-lb[b]	60–70[d]	60–70[d]	17[d]	—
Shear Strength (annealed strip, rod), 1000 psi[b]	42–45	—	45[d]	—
FABRICATING PROPERTIES				
Cold Workability	Excellent	Excellent	Poor	Excellent
Hot Workability	Excellent	Excellent	Excellent	Excellent
Hot Working Temp Range, F	1300–1600	1300–1600	1300–1600	1300–1700
Annealing Temp, F	900–1300	900–1250	1100–1125	850–1450
Machinability Index[c]	30	30	60	40
Joining				
Soft Soldering	Good	Good	Not recommended[g]	Excellent
Silver Alloy Brazing	Excellent	Excellent	Fair	Excellent
Oxyacetylene Welding	Excellent	Excellent	Poor	Excellent
Carbon Arc Welding	Excellent	Excellent	Fair	Excellent
Gas Shielded Arc Welding	Excellent	Excellent	Fair	Excellent
Resistance Welding	Excellent	Good	Fair	Excellent
CORROSION RESISTANCE	Excellent resistance to marine, industrial and rural atmospheres; most types of fresh and sea water; hot and cold dilute sulfuric, cold concentrated sulfuric, cold dilute hydrochloric, and most organic acids; hot and cold dilute alkalis and cold concentrated alkalis; chlorides and sulfates of light metals. Attacked by oxidizing acids and ammonium hydroxide; poor resistance to chlorides and sulfates of heavy metals			
AVAILABLE FORMS	Sheet, strip, plate, rod, wire, pipe, tube		Forgings, pressings	Rod, wire, sheet
USES	Welded unfired hot water storage heaters, heat exchangers, signs, hot headed fasteners, cast fittings, seamless tube or pipe, clutch disks	Cold headed cap and machine screws, wire and cable connectors, pole line hardware, marine hardware, valve components, tubing	Hot forged or pressed valve components, welding equipment, aircraft compression fittings, gears and pinions, large nuts and bolts	High strength mechanical fasteners; electrical, marine and chemical processing hardware. Sheet used for springs, sockets, etc. requiring high strength

[a] Properties of hardened material obtained by precipitation hardening 90 min at 700-850 F.
[b] Varies with grain size.
[c] Based on free-cutting brass = 100.
[d] Rod only.
[e] An alloy containing up to 2.6% Si is acceptable if the sum of all elements excepting Cu and Si is less than 0.3%.
[f] Solidus temperature not available.
[g] Can be soldered with special techniques.
[h] In fully heat treated condition.
[i] Elongation in 4D.

Nickel Silvers—Wrought

Type →	65-18	65-12	65-15	65-10	55-18
COMPOSITION, %	Cu 65, Ni 18, Zn 17	Cu 65, Ni 12, Zn 23	Cu 65, Ni 15, Zn 20	Cu 65, Ni 10, Zn 25	Cu 55, Ni 18, Zn 27
PHYSICAL PROPERTIES					
Density (68 F), lb/cu in.	0.316	0.314	0.314	0.313	0.314
Melting Temp Range, F	1960–2030	1900	1970	1870	1930
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	19	23	21	26	17
Coef of Ther Exp (68–572 F), per °F	9.0×10^{-6}	9.0×10^{-6}	9.0×10^{-6}	9.1×10^{-6}	9.3×10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.09	0.09	0.09	0.09	0.09
Elec Cond (68 F), % IACS	6	8	7	9	5.5
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	18×10^6	18×10^6	18×10^6	17.5×10^6	18×10^6
Ten Str, 1000 psi					
Annealed	56–60	52–61	53–61	49–63	60
Half Hard	70–86	73	74	73–85	—
Hard	85–103	85	85	86–105	100
Extra Hard	—	93	92	95–120	108
Yld Str, 1000 psi[a]					
Annealed	25–30	18–28	18–28	18–28	27
Half Hard	60–80	60	62	60	—
Hard	74–90	75	75	75	85
Extra Hard	—	79	79	76	90
Elong (in 2 in.), %					
Annealed	32–45	35–48	34–43	35–50	40
Half Hard	7–20	11	10	7–12	—
Hard	3	4	3	4–5	3
Extra Hard	—	2	2	3	2.5
Hardness (Rockwell)					
Annealed	B40–55	B22–55	B22–55	B22–52	B55
Half Hard	B78–83	B80	B80	B80	—
Hard	B87	B89	B87	B89	B91
Extra Hard	—	B92	B90	B92	B96
Shear Str, 1000 psi					
Annealed	—	41	41	41	—
Half Hard	—	47	47	50	—
Hard	—	52	52	55	—
Extra Hard	—	56	54	59	—
FABRICATING PROPERTIES					
Cold Workability	Excellent	Excellent	Excellent	Excellent	Good
Hot Workability	Poor	Poor	Poor	Poor	Poor
Annealing Temp, F	1100–1500	1100–1500	1100–1500	1100–1400	1100–1500
Machinability Index[b]	20	20	20	20	30
Joining	Soldering, excellent; silver alloy brazing, excellent; carbon arc welding, fair; butt resistance welding, good; oxyacetylene welding, good				
CORROSION RESISTANCE	Attacked rapidly by oxidizing acids. Resistant to sodium and potassium hydroxide but attacked rapidly by ammonium hydroxide and moist ammonia. Good resistance to rural and marine atmospheres and to fresh and salt waters. Subject to stress corrosion				
AVAILABLE FORMS	Sheet; strip; rods, bars, and shapes; wire; spring. Forging, extruding and casting alloys are also available				
USES	Most popular. Hardware, marine and automotive trim, camera parts, lighting fixtures, costume jewelry, screws, springs, slide fasteners	Slide fasteners, nameplates, decorative trim, camera parts	Optical equipment, etching stock, jewelry	Rivets, screws, slide fasteners, optical parts, hollow ware, nameplates	Excellent for springs. Springs and contacts in telephone equipment, electrical controls. Resistance wire, surgical and dental instruments, diaphragms, hardware

[a] 0.5% extension under load. [b] Based on free-cutting brass = 100.

Cupro-Nickels—Wrought

Type →	Cupro-Nickel, 30%	Cupro-Nickel, 20%	Cupro-Nickel, 10%
COMPOSITION, %	Cu 68.9, Ni 30, Fe 0.5, Mn 0.6	Cu bal, Ni 21, Fe 0.5, Mn 0.6	Cu 88.35, Ni 10, Fe 1.25, Mn 0.4
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.323	0.323	0.323
Melting Temp Range, F	2260–2140	2190–2100	2080–2020
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	17	21	26
Coef of Ther Exp (68–572 F), per °F	9.0×10^{-6}	9.1×10^{-6}	9.3×10^{-6}
Specific Heat, Btu/lb/°F	0.09	0.09	0.09
Electrical Resistivity (68 F), microhm-cm	37	27	15
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	22×10^6	20×10^6	18×10^6
Tensile Strength, 1000 psi			
Annealed[a]	54–60	45–51	44
Half Hard[b]	73	—	—
Hard[b]	80	—	—
Light Drawn[c]	75	80	60
Yield Strength (0.5% ext), 1000 psi			
Annealed[a]	20–22	—	15
Half Hard[b]	68	—	—
Hard[b]	73	—	—
Light Drawn[c]	—	75	57
Elongation (in 2 in.), %			
Annealed[a]	40–45	27	40
Half Hard[b]	12	—	—
Hard[b]	6	—	—
Light Drawn[c]	45	40	42
Hardness (Rockwell)			
Annealed[a]	B37–50	—	B10
Half Hard[b]	B80	—	—
Hard[b]	B85	—	—
Light Drawn[c]	B85	B81	B72
Creep Strength (0.001%/1000 hr), 1000 psi			
At 300 F	24	>25	>30
At 500 F	16	17	11
FABRICATING PROPERTIES			
Cold Workability	Good	Good	Good
Hot Workability	Good	Good	Good
Hot Working Temp, F	1700–1900	1650–1850	1550–1750
Annealing Temp, F	1200–1500	1200–1500	1100–1500
Machinability Index[d]	20	20	20
Joining			
Soft Soldering	Excellent	Excellent	Excellent
Silver Alloy Brazing	Excellent	Excellent	Excellent
Metal Arc Welding	Excellent	Excellent	Good
Gas Shielded Arc Welding	Excellent	Excellent	Excellent
Resistance Welding	Excellent	Excellent	Good
Oxyacetylene Welding	Fair	Fair	Fair
Carbon Arc Welding	Not recommended	Not recommended	Not recommended
CORROSION RESISTANCE	Resistant to attack by high velocity sea water, fresh water, steam; sulfuric, phosphoric and mild organic acids; ammonia and ammoniacal compounds, chlorides, sulfates, nitrates		
AVAILABLE FORMS	Plate, rod, strip, tube, wire		
USES	Condenser tubes and plates, heat exchanger tubes, salt water piping, evaporator tubes, process equipment, distillation tubes. ASME code permits use of Cupro-Nickel, 30% in heat exchangers and unfired pressure vessels up to 700 F		

[a] Properties of annealed materials vary with grain size. [b] Strip. [c] Tube. [d] Based on free-cutting brass –100.

Leaded Brasses and Bronzes—Cast

BBII Grade ➡	Leaded Tin Bronzes[a]		
	2A	2B	2C
COMPOSITION, %	Cu 88, Sn 6, Pb 1.5, Zn 4.5	Cu 87, Sn 8, Pb 1, Zn 4	Cu 87, Sn 8, Pb 1, Zn 2
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.311–0.318	0.314–0.320	0.314–0.320
Melting Temp Range, F	1830	1830–1570	1830–1570
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	—	28	28
Coef of Ther Exp (70–350 F), per °F	10.3×10^{-6}	10×10^{-6}	10×10^{-6}
Electrical Conductivity (68 F), % IACS	14	11	11
MECHANICAL PROPERTIES[b]			
Mod of Elast in Tension, psi	$12–16 \times 10^6$	$10.6–16 \times 10^6$	$10.6–16 \times 10^6$
Tensile Strength, 1000 psi	36–48	33–43	36–46
Yield Strength (0.5% ext), 1000 psi	16–21	16–24	18–26
Elongation (in 2 in.), %	25–40	18–30	15–25
Reduction of Area, %	16–33	15–30	12–26
Hardness (Brinell)	60–72	60–75	65–80
Impact Strength (Izod), ft-lb	11–16	12–15	7–10
Compr Yld Str (0.001-in. set), 1000 psi	12–15	9–11	12–14
FABRICATING PROPERTIES			
Casting Temp Range, F			
Light Castings	2000–2300	2100–2300	1200–2300
Heavy Castings	1900–2150	1920–2100	1920–2100
USES	Oil pumps, gears, bushings, high duty bearings, ornamental bronze	General utility structural bronze, pipe fittings, expansion joints, pressure valves	Bolts, nuts, gears, valves, pump pistons, pressure pipe fittings, expansion joints

BBII Grade ➡	High-Leaded Tin Bronzes[a]			
	3A	3B	3D	3E
COMPOSITION, %	Cu 80, Sn 10, Pb 10	Cu 83, Sn 7, Pb 7, Zn 3	Cu 78, Sn 7, Pb 15	Cu 71, Sn 5, Pb 24
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.321–0.328	0.320–0.322	0.329–0.340	0.332–0.343
Melting Temp (approx), F	1770	1800	1750	1700
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	27	—	—	—
Coef of Ther Exp (70–400 F), per °F	10.2×10^{-6}	10×10^{-6}	10.3×10^{-6}	—
MECHANICAL PROPERTIES[b]				
Mod of Elast in Tension	$8.5–13 \times 10^6$	—	$8.8–12.6 \times 10^6$	$9–12 \times 10^6$
Tensile Strength, 1000 psi	27–37	30–38	25–33	23–30
Yield Strength (0.5% ext), 1000 psi	15–22	17–21	14–20	11–15
Elongation (in 2 in.), %	8–12	12–20	10–18	7–16
Reduction of Area, %	5–11	10–22	8–15	5–12
Hardness (Brinell)	55–70	55–65	50–60	42–35
Impact Strength (Izod), ft-lb	2–8	—	4–6	4–6
Compr Yld Str (0.001-in. set), 1000 psi	12.5–16	—	13–16	12–14
FABRICATING PROPERTIES				
Casting Temp Range, F				
Light Castings	2000–2250	2000–2250	2000–2250	2000–2200
Heavy Castings	1850–2100	1900–2050	1900–2100	1850–2000
USES	General purpose bushing and bearing alloy	General purpose bearing alloy, bushings, automobile fittings	Bearing bronze for moderate pressure, mine water pump parts	Bearings operating at high speed and light or medium pressure

[a] Corrosion resistance generally the same as for nonleaded alloys of similar composition.
[b] Values are given for the as-cast condition.

Leaded Brasses and Bronzes—Cast

BBII Grade ➡	Leaded Red Brass[a]		Leaded Semi-Red Brass[a]	
	4A	4B	5A	5B
COMPOSITION, %	Cu 85, Sn 5, Pb 5, Zn 5	Cu 83, Sn 4, Pb 6, Zn 7	Cu 81, Sn 3, Pb 7, Zn 9	Cu 76, Sn 3, Pb 6, Zn 15
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.314–0.321	0.311–0.314	0.311–0.318	0.309–0.314
Melting Temp Range, F	1840–1550	1800	1800	1775
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	36	—	—	—
Coef of Ther Exp (70–400 F), per °F	10.9×10^{-6}	—	—	—
Elec Cond (68 F), % IACS	15	—	18	—
MECHANICAL PROPERTIES[b]				
Mod of Elast in Tension, psi	$9.1–14.8 \times 10^6$	—	$7.7–14.3 \times 10^6$	$10–14 \times 10^6$
Ten Str, 1000 psi	33–46	30–38	29–39	30–40
Yld Str (0.5% ext), 1000 psi	17–24	12–17	13–17	12–16
Elongation (in 2 in.), %	20–35	15–27	18–30	20–35
Red. of Area, %	17–32	12–25	15–27	15–30
Hardness (Brinell)	55–65	50–60	50–60	50–60
Impact Str (Izod), ft-lb	6–12	—	6–10	—
Compr Yld Str (0.001-in. set), 1000 psi	10–12	11–12	—	8–10
FABRICATING PROPERTIES				
Casting Temp Range, F				
Light Castings	2100–2350	2100–2300	2100–2300	2100–2300
Heavy Castings	1950–2150	1950–2150	1950–2150	1950–2150
USES	Low pressure valve bodies, pipe fittings, pump impellers, plumbing goods	Air, gas and water fittings, valves, pump parts, hardware, carburetors	Low pressure valves and fittings, hardware, plumbing fittings	Plumbing fixtures, air and gas fittings, hardware, low pressure valves and fittings

BBII Grade ➡	Leaded Nickel Brass and Bronze[a]			
	10A	10B	11A	11B
COMPOSITION, %	Cu 57, Sn 2, Pb 9, Zn 20, Ni 12	Cu 60, Sn 3, Pb 5, Zn 16, Ni 16	Cu 64, Sn 4, Pb 4, Zn 8, Ni 20	Cu 66.5, Sn 5, Pb 1.5, Zn 2, Ni 25
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.318–0.322	0.318–0.322	0.318–0.322	0.318–0.322
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	16	16	14	15
Elec Cond (68 F), % IACS	5–7	5–6	4.5–5.5	4–5
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	$15–16.5 \times 10^6$	—	$17–18 \times 10^6$	$19–22 \times 10^6$
Ten Str, 1000 psi	30–40	35–45	40–60	50–65
Yld Str (0.5% extn), 1000 psi	15–20	17–24	17–30	26–40
Elongation (in 2 in.), %	10–25	15–30	15–25	15–25
Red. of Area, %	7–20	15–30	11–22	15–30
Hardness (Brinell)	50–60	65–80	76–120	120–150
FABRICATING PROPERTIES				
Casting Temp Range, F				
Light Castings	2200–2400	2250–2450	2300–2600	2400–2600
Heavy Castings	2000–2200	2050–2250	2250–2400	2300–2400
USES	Hardware fittings, valves and trim, plumbing fittings	Valves and fittings, boat and railroad car fittings, pipe fittings	Marine fittings, furniture trim, building trim, valves, hardware	Dairy and soda fountain parts, valves and seats for elevated temp

[a] Corrosion resistance generally the same as for nonleaded alloys of similar composition.
[b] Values are given for the as-cast condition.

Yellow Brasses—Cast

BBII Grade ➡	High Strength Yellow Brass*		
	7A	8A	8C
COMPOSITION, %	Cu 56–62, Sn 0.5–1, Pb 0.5–1, Fe 0.75–1.5, Al 0.25–1, Mn 0.1–0.5, Zn bal	Cu 56–59, Sn 1 max, Pb 0.3 max, Fe 0.75–2, Al 0.75–1.5, Mn 0.1–1, Zn bal	Cu 60–68, Fb 0.1 max, Fe 2–4, Al 4–7.5, Mn 3–4.5, Zn bal
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.289–0.303	0.289–0.307	0.278–0.289
Melting Temp Range, F	1675–1725	1660–1700	1650–1700
Coef of Ther Exp (70–400 F), per °F	11.4×10^{-6}	12×10^{-6}	11×10^{-6}
Electrical Conductivity (68 F), % IACS	20–24	16–20	10–14
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	$12–14 \times 10^6$	$13–15 \times 10^6$	$15–16.5 \times 10^6$
Tensile Strength, 1000 psi	60–78	70–88	110–120
Yield Strength (0.5% ext), 1000 psi	25–40	28–40	65–90
Elongation (in 2 in.), %	15–30	20–35	12–18
Red. of Area, %	15–30	20–40	5–18
Hardness (Brinell)	80–95	90–120	170–225
Impact Strength (Izod), ft-lb	20–40	20–40	7–12
Compr Yld Str (0.001-in. set), 1000 psi	20–26	22–26	55–65
FABRICATING PROPERTIES			
Casting Temp Range, F			
Light Castings	1900–2050	1900–2000	1950–2150
Heavy Castings	1750–1900	1750–1900	1800–1950
USES	Valve stems, marine castings, pump bodies, gears, brackets	Propeller hubs and blades, valve stems, machine parts, gears	Spur gears, cams, bridge parts, screw down nuts, bearings

BBII Grade ➡	Leaded Yellow Brass*		
	6A	6B	6C
COMPOSITION, %	Cu 71, Zn 25, Pb 3, Sn 1	Cu 67, Zn 29, Pb 3, Sn 1	Cu 60, Zn 37.75, Pb 1, Sn 1, Al 0.25
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.305–0.309	0.303–0.307	0.300–0.360
Melting Temp Range, F	1700–1750	1700–1725	1675–1725
Coef of Ther Exp (70–200 F), per °F	11.5×10^{-6}	11.2×10^{-6}	12×10^{-6}
Electrical Conductivity (68 F), % IACS	15–22	18–25	20–26
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	$11–14 \times 10^6$	$12–14 \times 10^6$	$13–15 \times 10^6$
Tensile Strength, 1000 psi	35–40	30–38	40–45
Yield Strength (0.5% ext), 1000 psi	12–14	11–15	14–20
Elongation (in 2 in.), %	25–40	20–35	15–25
Red. of Area, %	20–40	15–30	18–30
Hardness (Brinell)	40–55	40–60	50–75
Compr Yld Str (0.001-in. set), 1000 psi	8–10	8–10	—
FABRICATING PROPERTIES			
Casting Temp Range, F			
Light Castings	2000–2100	1950–2100	1950–2150
Heavy Castings	1850–2000	1850–1950	1800–2000
USES	Plumber's fittings and fixtures, ferrules, hardware, andirons	Valves and fittings, spray nozzles, battery clamps, ship fittings	Ship fittings, plumber's flanges, hardware, Navy yellow brass

* Corrosion resistance generally the same as for nonleaded alloys of similar composition.

Aluminum Bronzes—Cast

BBII Grade ➡	9A	9B	9C	9D
COMPOSITION, %	Cu 87.5, Al 9, Fe 3.5	Cu 89, Al 10, Fe 1	Cu 83 min, Al 10–11.5, Fe 3–5, Ni 2.5 max, Mn 0.5 max	Cu 81, Al 11, Fe 4, Ni 4
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.267	0.270	0.272	0.273
Melting Point Range, F	—	—	1880–1900	1937
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	—	33	—	22
Coef of Ther Exp, per °F	9.5 x 10^{-6} [a]	9.5 x 10^{-6} [b]	9.0 x 10^{-6} [b]	—
Elec Cond (68 F), % IACS	13	13.5	12	7.5
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	17 x 10^{6}	15 x 10^{6}	18 x 10^{6}	17 x 10^{6}
Ten Str, 1000 psi				
Sand Cast	75	87	75	95
Sand Cast & Heat Treated	—	90 [c]	105 [d]	115 [e]
Yld Str (0.5% ext), 1000 psi				
Sand Cast	27	32	35	45
Sand Cast & Heat Treated	—	40 [c]	52 [d]	70 [e]
Elongation (in 2 in.), %				
Sand Cast	35	27	18	7
Sand Cast & Heat Treated	—	15 [c]	10 [d]	5 [e]
Hardness (Brinell)				
Sand Cast	120	120	155	195
Sand Cast & Heat Treated	—	180 [c]	230 [d]	235 [e]
THERMAL TREATMENT				
Normalizing Temp, F	Heat to 1500, furnace cool to 1000, air cool			
Quenching Temp, F	1600–1700	1600–1700	1600–1700	1600–1700
Tempering Temp, F	700–1200	700–1200	700–1200	700–1200
FABRICATING PROPERTIES				
Castability	Because of narrow freezing ranges and high shrinkage, aluminum bronzes are difficult to cast. In addition, they are sensitive to gases. In melting, precautions must be taken to minimize stirring and breaking the oxide skin on the surface of the melt to prevent absorption of gases. In pouring, agitation must be avoided, and castings are generally bottom gated to reduce turbulence. Shrinkage difficulties are overcome by use of large risers (to feed the casting) and chills			
Machinability Index (free-cutting brass = 100)	20–30	20–30	20–30	20–30
Weldability	Can be welded by carbon arc, inert-gas arc and resistance methods. Can be brazed with silver brazing alloys, but require special fluxes			
CORROSION RESISTANCE	Generally good resistance to atmosphere, water and salt water, and salt solutions. Some resistance to alkaline solutions and nonoxidizing inorganic acids. Poor resistance to ammonia compounds, ferric salts and oxidizing inorganic acids			
USES	Machine parts, pump impellers and castings, gears, rolling mill bearings, segments and washers, bearings, chemical plant equipment, pickling equipment such as chains and hooks, marine propellers, pump casings, fittings			

[a] 70-250 F. [b] 70-500 F.
[c] Water quenched from 1625 F, tempered at 1125 F, water quenched.
[d] Water quenched from 1625 F, tempered at 1000 F, water quenched.
[e] Water quenched from 1625 F, tempered at 1150 F, water quenched.

Lead and Its Alloys—Cast, Wrought[a]

Type ➡	Chemical Lead	Common Lead (soft lead)	Tellurium Lead
COMPOSITION, %	Pb 99.90+	Pb 99.73+	Te 0.05, Cu 0.06 max
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.41	0.41	0.41
Melting Point, F	618	621	617
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	19.6	19.6	19.3
Coef of Ther Exp, per °F	16.3×10^{-6}	16.3×10^{-6}	16×10^{-6}
Specific Heat (32 F), Btu/lb/°F	0.031	0.031	0.031
Electrical Resistivity (68 F), microhm-cm	—	20.6	—
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	2×10^6	2×10^6	1.5×10^6
Tensile Strength, psi			
Rolled	2450	2090	—
Extruded	2200	2000	—
Sand Cast	—	1800	—
Chill Cast	2200	2000	—
Yield Strength, psi			
Rolled	1640	—	—
Extruded	—	—	1500
Sand Cast	—	800	—
Elongation (in 2 in.), %			
Rolled	57	43	40
Extruded	48	—	—
Sand Cast	—	30	—
Chill Cast	40	47	—
Reduction of Area, %			
Sand Cast	—	100	—
Chill Cast	—	100	—
Hardness (Brinell)			
Extruded	—	—	6
Sand Cast	—	3.2–4.5	—
Chill Cast	—	4.2	—
Impact Strength (Charpy, chill cast), ft-lb	—	10	—
Endurance Limit (10^7 cycles), psi			
Extruded & Aged	725	470	1000
Sand Cast	—	470	—
Shear Strength, psi			
Sand Cast	—	1820	—
Chill Cast	—	1820	—
Creep Strength (0.1% per yr, rolled, 85 F), psi	300	250	300
FABRICATING PROPERTIES	Formed by cold rolling and extrusion		
Casting Temp Range, F	790–850	790–850	790–850
Joining	Soft solder with 50-50 or 40-60 solder using rosin or stearic acid flux. Oxyhydrogen welding (lead burning); slightly reducing flame; no flux		
CORROSION RESISTANCE	Resistant to sulfuric, sulfurous, phosphoric and chromic acids. Attacked by acetic, formic and nitric acids. Resistant to atmosphere and fresh and salt water		
AVAILABLE FORMS	Castings, rolled and extruded shapes, sheet		
USES	Nuclear reflectors and shields; anodes for cathodic protection		
	Chemical apparatus	Storage batteries, cable sheath, ammunition, calking, alloying, coatings, liquid baths for heat treating	Chemical apparatus

[a] See also Tin-Lead-Antimony Alloys.

Lead and Its Alloys—Wrought

Type →	1% Sb-Lead	Hard Lead	Hard Lead	8% Sb-Lead	Grid Metal (7-12% Sb)
COMPOSITION, %	Sb 1	Sb 4	Sb 6	Sb 8	Sb 9
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.406	0.398	0.393	0.388	0.385
Melting Temp Range, F	608–595	570–486	545–486	520–486	509–486
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	19	18	17	16	16
Coef of Ther Exp (68–212 F), per °F	16×10^{-6}	15.5×10^{-6}	15.4×10^{-6}	14.5×10^{-6}	14.4×10^{-6}
Spec Ht, Btu/lb/°F	0.031	0.032	0.032	0.032	0.032
Elec Res (68 F), microhm-cm	22	24	25	26.5	27.1
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	2×10^6	—	—	—	—
Ten Str, 1000 psi					
Rolled	3.0	4.0	4.1	4.6	4.7
Extruded	2.9	3.1	3.3	3.3	—
Extruded & Aged	3.0	—	—	—	—
Chill Cast	3.4	5.6	6.8	7.4	7.4
Elong (in 2 in.), %					
Rolled	60	48	47	31	17
Extruded	58	58	65	75	—
Extruded & Aged	50	—	—	—	75
Chill Cast	16	22	24	19	—
Hardness (Brinell)					
Rolled	5.9	8	—	9.5	7.8
Extruded	5.1	8.9	10.7	12.4	—
Extruded & Aged	7	—	—	—	—
Chill Cast	7	10	11.8	13.3	15.4
Endurance Limit, psi[a]					
Rolled	—	1500	1500	1750	—
Extruded	—	—	1200	—	—
Extruded & Aged	1150	—	—	—	—
Chill Cast	—	—	2500	—	2700
Creep Str (86 F)[b]					
Rolled	—	250	400	425	400
Extruded	350	210	—	—	—
FABRICATING PROPERTIES					
Casting Temp Range, F	750–925	750–925	750–850	750–925	750–925
Joining	Soft solder with 50–50 or 40–60 solder using rosin or stearic acid flux. Oxyhydrogen welding (lead burning): no flux, slightly reducing flame				
CORROSION RESISTANCE	Similar to soft lead (see opposite page)				
USES	Nuclear reflectors and shields; anodes for cathodic protection				
	Cable sheathing	Rolled sheet for roofing and flashing; extruded pipe for corrosion resistance applications requiring greater strength than soft lead			Battery grids

[a] 2×10^7 cycles.
[b] 1% extension in 10,000 hr.

Magnesium Alloys—Wrought

ASTM Type ➡	M1A-F	AZ61A-F	AZ80A-T5	ZK60A-T5	(P)ZK60B-T5	ZK21A-F
COMPOSITION, %	Mn 1.20 min	Al 5.8–7.2, Zn 0.4–1.5, Mn 0.15 min	Al 7.8–9.2, Zn 0.2, Mn 0.15 min	Zn 4.8–6.2, Zr 0.45 min	Zn 4.8–6.8, Zr 0.45 min	Zn 2.0–2.6, Zr 0.45–0.8
PHYSICAL PROPERTIES						
Density, lb/cu in.	0.064	0.065	0.065	0.066	0.066	0.064
Melting Temp Range, F	1198–1200	950–1140	900–1115	968–1175	968–1175	—
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	80	34	29	68–70	70	—
Coef of Ther Exp, per °F						
68 F	14×10^{-6}	14×10^{-6}	14×10^{-6}	14×10^{-6}	14×10^{-6}	14×10^{-6}
68 to 750 F	16×10^{-6}	16×10^{-6}	16×10^{-6}	16×10^{-6}	16×10^{-6}	16×10^{-6}
Spec Ht (68°F), Btu/lb/°F	0.245	0.245	0.245	0.245	0.245	0.245
Elec Res (68 F), microhm-cm	5.0	12.5	14.5	6.0–5.7	5.7	—
MECHANICAL PROPERTIES						
Mod of Elast in Tension, psi	6.5×10^6	6.5×10^6	6.5×10^6	6.5×10^6	6.5×10^6	6.5×10^6
Ten Str, 1000 psi						
Extruded[a]	35–38	41–46	50–55	50–53	49	41–42
Forged	36	43	50	49	—	—
Yld Str, 1000 psi						
Extruded[a]	21–26	24–33	38–40	40–44	38	33–35
Forged	23	26	34	38	—	—
Elong (in 2 in.), %						
Extruded[a]	5–12	14–17	6–8	11–14	17	6–10
Forged	7	12	6	13	—	—
Compr Yld Str, 1000 psi						
Extruded[a]	9–12	16–21	31–34	30–36	40	17–25
Forged	—	17	28	28	—	—
Hardness (Brinell)						
Extruded[a]	42–44	50–60	82	82	—	—
Forged	47	55	72	—	—	—
Shear Str, 1000 psi						
Extruded	18	20	24	24–26	26	—
Forged	18	20	23	—	—	—
Fatigue Strength[b] (10^8 cycles), 1000 psi						
Extruded	10–13	18–23	20–24	17–23	17–23	—
Forged	—	17–22	16–18	16–18	—	—
Impact Str (Charpy), ft-lb						
Extruded	1.5	4.5	1.3	3	2.6	—
Forged	—	—	—	—	—	—
FABRICATING PROPERTIES						
Hot Working Temp Range, F[d]	550–650	450–650	350–375	300–500	300–500	300–500
Weldability[c]						
Inert-Gas Arc	A	B	B	D	D	B
Elec Res	A	A	A	A	A	A
Stress Relief Temp, F	—	500	400	—	—	—
Machinability Index (free-cutting brass=100)	500	500	500	500	500	500
Hot Formability[c]	A	B	C	A	A	A
Cold Formability[c]	B	C	D	C	C	C
CORROSION RESISTANCE	Good resistance to atmosphere; attacked by salt water unless finished					
AVAILABLE FORMS	Rod, bar, extruded shapes, tubing (except AZ80A), forgings				Rod, bar, extruded shapes	Rod, bar, extruded shapes, tubing
USES	Aircraft and missile parts, ordnance vehicles, automotive and truck parts, electronic equipment, wave guides, office machines, reciprocating machinery parts, drillable oil well casing tools, hand tools, levels, material handling equipment, concrete forms, plastering tools, jigs and fixtures, luggage and furniture, boats, sporting goods, wheels					

[a] Generally, strengths and hardness of extruded bar are highest, extruded tubing lowest, and extruded shapes intermediate in the ranges of values given.
[b] Rotating-beam fatigue.
[c] Letter A indicates most favorable, B less favorable, etc. Relative to magnesium alloys only.
[d] Higher working temperatures can be used if they do not require heating aged alloys above the aging temperature.

Magnesium Alloys—Wrought

ASTM Type →	ZE10A-H24 [a]	AZ31B-H24 [b]	HK31A-H24 [a]	HM21A-T8	HM31A-T5
COMPOSITION, %	Zn 1.0–1.5, Rare earths 0.12–0.22	Al 2.5–3.5, Zn 0.7–1.3, Mn 0.20	Th 2.5–4.0, Zr 0.45–1.0	Th 1.5–2.5, Mn 0.45–1.1	Th 2.5–3.5, Mn 1.2 min
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.063	0.064	0.065	0.064	0.065
Melting Temp Range, F	1100–1195	1050–1170	1092–1195	1121–1202	1121–1202
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	77	44	66	79	60
Coef of Ther Exp (68 to 750 F), per °F	16×10^{-6}	16×10^{-6}	16×10^{-6}	16×10^{-6}	16×10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.245	0.245	0.245	0.245	0.245
Elec Res (68 F), microhm-cm	5.2	9.2	6.1	5.0	6.6
MECHANICAL PROPERTIES [c]					
Mod of Elast in Tension, psi					
75 F	6.5×10^6	6.5×10^6	6.4×10^6	6.4×10^6	6.5×10^6
500 F	—	—	5.2×10^6	5.8×10^6	5.7×10^6
Ten Str, 1000 psi [d]					
75 F	34–38	42, 38–39	37	34	42
500 F	—	—	20	15	21
Yield Str, 1000 psi [d]					
75 F	19–28	32, 24–27	29	21	33
500 F	—	—	17	13	19
Elong (in 2 in.), % (75 F) [d]	8–12	15, 18–19	8	10	10
Compr Yld Str, 1000 psi [d]					
75 F	16–26	24–25, 12–14	23	15	25
500 F	—	—	20	13	19
Shear Str, 1000 psi [d]					
75 F	—	23, —	27	19	23
500 F	—	—	12	11	11
Fatigue Str, 1000 psi [e]					
75 F	20–24	20–24	18–20	16–18	12–14
400 F	—	—	9–14	12–14	—
Creep Str (stress to give 0.5% total ext in 100 hr), 1000 psi					
300 F	—	1.5	20	16	21
500 F	—	—	—	9	13
FABRICATING PROPERTIES					
Hot Working Temp Range, F	325–425	325–425	550–700	650–800	650–800
Weldability [f]					
Inert-Gas Arc	A	A	A	A	A
Elec Res	A	A	A	A	A
Stress Relief Temp, F	—	500	—	—	—
Machinability Index (free-cutting brass = 100)	500	500	500	500	500
Hot Formability [f]	A	A	A	A	A
Cold Formability [f]	B+	B	C	C	C
CORROSION RESISTANCE	Good resistance to atmosphere; attacked by salt water unless finished				
AVAILABLE FORMS	Sheet and plate				Extrusions
USES	Aircraft and missile parts, ordnance vehicles, truck bodies, electronic cabinets, chassis, covers and reflectors, office machines, appliances, materials handling equipment, concrete forms, jigs and fixtures, templates, foundry pattern plate, deck plate, photoengraving plate, luggage, furniture, sporting goods		Aircraft and missile components		

[a] ZE10A and HK31A also available in -0 temper.

[b] AZ31B sheet and plate also available in -0 temper. AZ31B plate also available in -H26 temper. AZ31B also available as special bending sheet in the -0 temper and 0.040-0.190-in. thickness for cold bending around a mandrel radius of 2-3 or more times the sheet thickness.

[c] HM31A-T5 properties for extrusions (to 4 sq in.) only. ZE10A-H24, HM21A-T8 and HK31A-H24 properties for sheet only. AZ31B-H24 properties for sheet only except as indicated.

[d] AZ31B-H24 values are for sheet and plate, respectively.

[e] Axial load fatigue of ZE10A-H24 and AZ31B-H24 sheet, 10^7 cycles, R = ½. Axial load fatigue of HM21A-T8 and HK31A-H24 sheet, 10^7 cycles, R = ¼. Rotating beam fatigue of HM31A-T5 extrusions, 10^8 cycles, R = 1.

[f] Letter A indicates most favorable, B less favorable, etc. Relative to magnesium alloys only.

Magnesium Alloys—Cast

ASTM Type →	AZ63A	AZ81A	AZ91A	AZ91C	AZ92A	AM100A
COMPOSITION, %	Al 5.3–6.7, Zn 2.5–3.5, Mn 0.15 min	Al 7.0–8.1, Zn 0.40–1.0, Mn 0.13 min	Al 8.3–9.7, Zn 0.4–1.0, Mn 0.13 min	Al 8.1–9.3, Zn 0.40–1.0, Mn 0.13 min	Al 8.3–9.7, Zn 1.6–2.4, Mn 0.10 min	Al 8.3–9.7, Zn 0.3 max, Mn 0.10 min
PHYSICAL PROPERTIES						
Density, lb/cu in.	0.066	0.065	0.065	0.065	0.066	0.065
Melting Temp Range, F	850–1135	1115	875–1120	875–1105	830–1110	865–1100
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	29–39	29	31	27–31	27–34	24–34
Coef of Ther Exp, per °F						
68 F	14×10^{-6}	14×10^{-6}	14×10^{-6}	14×10^{-6}	14×10^{-6}	14×10^{-6}
68–750 F	16×10^{-6}	16×10^{-6}	16×10^{-6}	16×10^{-6}	16×10^{-6}	16×10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.245	0.245	0.245	0.245	0.245	0.245
Elec Res (68 F), microhm-cm	11–14	15	14	13–16	12–17	11–17
MECHANICAL PROPERTIES[a]						
Mod of Elast in Tension, psi	6.5×10^6	6.5×10^6	6.5×10^6	6.5×10^6	6.5×10^6	6.5×10^6
Ten Str, 1000 psi						
As Cast	29	—	34	24	24	22
Sol'n Treated	40	40	—	40	40	40
Aged[b]	30, 40	—, —	—, —	—, 40	26, 40	—, 40
Yld Str, 1000 psi						
As Cast	14	—	23	14	14	12
Sol'n Treated	13	12	—	12	14	13
Aged[b]	14, 19	—, —	—, —	—, 19	16, 21	—, 16
Elong (in 2 in.), %						
As Cast	6	—	3	2	2	2
Sol'n Treated	12	15	—	14	9	10
Aged[b]	4, 5	—, —	—, —	—, 5	2, 2	—, 4
Hardness (Brinell)						
As Cast	50	—	60	52	65	—
Sol'n Treated	55	55	—	53	63	—
Aged[b]	55, 73	—, —	—, —	—, 66	80, 84	—, —
Shear Str, 1000 psi						
As Cast	16	—	20	16	16	—
Sol'n Treated	17	17	—	17	17	—
Aged[b]	17, 19	—, —	—, —	—, 19	16, 20	—, —
Fatigue Str (10^8 cycles), 1000 psi[c]						
As Cast	9–12	—	10–14	11–14	12–14	—
Sol'n Treated	12–17	11–14	—	12–15	12–15	—
Sol'n Treated and Aged	11–15	—	—	10–13	11–15	—
THERMAL TREATMENT						
Solution Temp, F	730	780	—	780	770	780
Aging Temp, F	425	—	—	420	500	425
FABRICATING PROPERTIES						
Weldability[d]						
Inert-Gas Arc	D	B	—	C	C	A
Stress Relief Temp, F	500	500	—	500	500	500
Machinability Index (free-cutting brass=100)	500	500	500	500	500	500
CORROSION RESISTANCE	Good resistance to atmosphere; attacked by salt water unless finished					
AVAILABLE FORMS	Sand and permanent mold castings		Die castings	Sand and permanent mold castings		Permanent mold castings
USES	Wheels, aircraft and missile parts, ordnance equipment, automotive and truck parts, electronic housings, office machines, appliances, reciprocating machinery parts, cameras and optical equipment, hand tools, material handling equipment, sporting goods, griddles					

[a] Separately-cast test bars.
[b] First value obtained by artificial aging only; second value by solution treating and artificial aging.
[c] Rotating-beam fatigue.
[d] Letter A indicates most favorable, B less favorable, etc. Relative to magnesium alloys only.

Magnesium Alloys—Cast

ASTM Type →	ZE41A-T5	ZK51A-T5	ZH62A-T5	K1-A
COMPOSITION, %	Zn 3.5–5.0, rare earths 0.75–1.75, Zr 0.40–1.0	Zn 3.6–5.5, Zr 0.55–1.0	Zn 5.2–6.2, Th 1.4–2.2, Zr 0.50–1.0	Zr 0.7
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.066	0.065	0.067	0.063
Melting Temp Range, F	—	1040–1175	—	1202[d]
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	—	48	63	60
Coef of Ther Exp, per °F				
68 F	14×10^{-6}	14×10^{-6}	14×10^{-6}	—
68–750 F	16×10^{-6}	16×10^{-6}	16×10^{-6}	15×10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.245	0.245	0.245	—
Elec Res (68 F), microhm-cm	—	8.4	6.5	5.7
MECHANICAL PROPERTIES[a]				
Mod of Elast in Tension, psi	6.5×10^6	6.5×10^6	6.5×10^6	6.5×10^6
Ten Str, 1000 psi	30	40	40	26
Yld Str, 1000 psi	20	24	25	8
Elong (in 2 in.), %	3.5	8	6	19
Hardness (Brinell)	62	65	62	—
Shear Str, 1000 psi	22	22	23	8
Fatigue Str (10^8 cycles), 1000 psi[b]	—	8–10	—	—
THERMAL TREATMENT				
Aging Temp, F	350	350	350	—
FABRICATING PROPERTIES				
Weldability (inert-gas arc)[c]	B	D	D	B
Machinability Index (free-cutting brass=100)	500	500	500	500
CORROSION RESISTANCE	Good resistance to atmosphere; attacked by salt water unless finished			
AVAILABLE FORMS	Sand and permanent mold castings			Sand and die castings
USES	Aircraft and missile parts, ordnance equipment			

[a] Separately-cast test bars.
[b] Rotating-beam fatigue.
[c] Letter A indicates most favorable, B less favorable, etc. Relative to magnesium alloys only.
[d] Melting point.

continued on next page

Magnesium Alloys—Cast

ASTM Type →	QE22A-T6	EZ33A-T5	HK31A-T6	HZ32A-T5	EX31XA-T6
COMPOSITION, %	Ag 2.0–3.0, rare earths[d] 1.75–2.25, Zr 0.40–1.0	Rare earths[e] 2.5–4.0, Zn 2.0–3.1, Zr 0.50–1.0	Th 2.5–4.0, Zr 0.50–1.0	Th 2.5–4.0, Zn 1.7–2.5, Zr 0.50–1.0	Rare earths[d] 2.5–4.0, Zr 0.4–1.0
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.065	0.066	0.065	0.066	0.064
Melting Temp Range, F	—	1110–1189	1092–1195	1026–1198	—
Ther Cond, Btu/hr/sq ft/°F/ft					
68 F	—	58	52	62	36
600 F	—	69	68	74	43
Coef of Ther Exp, per °F					
68 F	14×10^{-6}	14×10^{-6}	14×10^{-6}	14×10^{-6}	14.5×10^{-6}
68–750 F	16×10^{-6}	16×10^{-6}	16×10^{-6}	16×10^{-6}	14.5×10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.245	0.245	0.245	0.245	—
Elec Res, microhm-cm					
68 F	—	7.0	7.7	6.5	7.2
600 F	—	12.1	12.4	11.3	12.0
MECHANICAL PROPERTIES[a]					
Mod of Elast in Tension, psi					
75 F	—	6.5×10^6	6.5×10^6	6.5×10^6	—
300 F	—	6.0×10^6	6.1×10^6	5.9×10^6	—
600 F	—	5.4×10^6	5.6×10^6	5.6×10^6	—
Ten Str, 1000 psi					
75 F	40	23	31	29	35
400 F	28	21	24	17	29
700 F	7	—	13	10	15[f]
Yld Str, 1000 psi					
75 F	30	16	16	15	22
400 F	25	12	14	10	20
700 F	6	—	8	7	13[f]
Elong (in 2 in.), %, 75 F	4	3	6	6	5
Hardness (Brinell)	—	50	55	57	64
Shear Str, 1000 psi					
75 F	—	20	21	20	23
400 F	—	17	16	14	19
600 F	—	10	13	10	11
Fatigue Str, 1000 psi[b] (10^8 cycles), 75 F	15–17	9–11	9–11	9–11	—
Creep Str (stress to give 0.5% total ext in 100 hr), 1000 psi					
400 F	14	10	15	10	10–13
500 F	—	4	10	8	3–4
600 F	—	1.5	3.5	5	1.2–1.8
FABRICATING PROPERTIES					
Weldability (inert-gas arc)[c]	—	A	A	A	—
Machinability Index (free-cutting brass=100)	500	500	500	500	—
CORROSION RESISTANCE	Good resistance to atmosphere; attacked by salt water unless finished				
AVAILABLE FORMS	Sand and permanent mold castings				Sand castings
SERVICE TEMPERATURE, MAXIMUM F	500	500	700	700	550
USES	Aircraft and missile components				Aircraft and missile components up to 550 F; airframe and engine components for 1000 hr at 450 F

[a] Separately-cast test bars. [b] Rotating-beam fatigue.
[c] Letter A indicates most favorable, B less favorable, etc. Relative to magnesium alloys only.
[d] Rare earths are present as didymium, essentially 85% neodymium and 15% praseodymium.
[e] Rare earths are present as mischmetal. [f] At 600 F.

Columbium, Tantalum, Tungsten, Molybdenum—Wrought

Metal →	Columbium	Tantalum	Tungsten	Molybdenum
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.31	0.60	0.70	0.37
Melting Point, F	4379	5425	6152	4760
Ther Cond (212 F), Btu/hr/sq ft/ °F/ft	31.5	31.5	96.6	84.5
Coef of Ther Exp (70 F), per °F	3.82×10^{-6}[a]	3.6×10^{-6}	2.2×10^{-6}	3.0×10^{-6}
Specific Heat, Btu/lb/°F	0.065	0.036	0.034	0.065
Elec Res (68 F), microhm-cm	14.2	12.4	5.48[b]	5.17[b]
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	—	27×10^6	50×10^6	42×10^6
Ten Str, 1000 psi				
Annealed	50	50–100	—	85–130[c], 88[d]
Cold Worked	100	110–180	70–300	120–175[c]
Yld Str, 1000 psi				
Annealed	—	—	—	—
Cold Worked	—	-	—	—
Elong (in 2 in.), %				
Annealed	30	11–40	—	4–7[c], 42[d]
Cold Worked	5	1–1.5	0	1[c]
Hardness (Rockwell)				
Annealed	E80	E60	—	B95[c]
Cold Worked	E100	E95	C37–C47	C22–27[c]
FABRICATING PROPERTIES				
Workability	Easily cold worked	Easily cold worked	Must be hot worked except fine wire	Thin sheet and wire can be cold worked, heavier material hot worked
Annealing Temp, F	1950 in vacuum	1950 in vacuum	1830 in protective atm	Anneal to specified mechanical properties
Machinability	Like cold rolled steel, with proper lubricants	Like cold rolled steel, with proper lubricants	Difficult, even with special tools and methods; grinding recommended	Like cast iron, but tool life is shorter
Joining	Weldable to itself and other metals by resistance or inert arc welding. Special methods necessary	Weldable to itself and other metals by resistance or inert arc welding. Special methods necessary	Weldable to itself by inert arc with special methods; to other metals by brazing or resistance welding	Thin sheet can be resistance welded, heavier sections inert arc welded with special methods. Can be brazed to other metals
CORROSION RESISTANCE	Res to most acids (except hydrofluoric); res to most liquid metals. Less res to alkalis	More res than columbium to acids (except hydrofluoric); res to most liquid metals, metallic salts and compounds. Less res to alkalis	Res most acids and alkalis to 212 F, attacked by nitric-hydrofluoric mixture at rm temp, by aqua regia at 212 F	Moderately res to acids and alkalis up to 212 F, attacked by nitric-hydrofluoric mixture at rm temp, by aqua regia at 212 F
AVAILABLE FORMS	Bar, rod, wire, sheet, foil, tubing, powder, fabricated parts	Bar, rod, wire, sheet, foil, tubing, powder, fabricated parts	Bar, rod, wire, sheet, powder, fabricated parts	Bar, rod, wire, sheet, tubing, powder, fabricated parts
USES	Nuclear reactors, missles, rockets, chemical plant equipment, electronic tubes	Capacitors, chemical plant equipment, electronic tubes, rectifiers, surgical implants, nuclear reactors, missiles, rockets, aircraft	Lamp filaments, electrical contacts, nuclear reactors, rockets, missiles, aircraft, radiation shields, electronic tube parts, x-ray targets	Glass melting electrodes, electronic tube parts, furnace heating elements, electrical contacts, aircraft,missile and rocket structures, guidance systems

[a] 32–1832 F. [b] 32 F. [c] From powder. [d] Arc melted.

Nickel and Its Alloys—Wrought

Type →	A Nickel	Low Carbon Nickel	Duranickel	Monel	K Monel
COMPOSITION, %	Ni 99.00, Cu 0.10, Fe 0.15, Si 0.05, Mn 0.25, C 0.05, S 0.005	Ni 99.00, Cu 0.10, Fe 0.15, Si 0.05, Mn 0.25, C 0.01, S 0.005	Ni 94.00, Cu 0.05, Fe 0.35, Al 4.50, Si 0.50, Ti 0.50, Mn 0.30, C 0.25, S 0.005	Ni 67.00, Cu 30.00, Fe 1.40, Si 0.10, Mn 1.00, C 0.15, S 0.035	Ni 66.00, Cu 29.00, Fe 1.00, Al 2.75, Si 0.50, Ti 0.50, Mn 0.75, C 0.15, S 0.005
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.321	0.321	0.298	0.319	0.306
Melting Temp Range, F	2615–2635	2615–2635	2550–2620	2370–2460	2400–2460
Ther Cond (80–212 F), Btu/hr/sq ft/°F/ft	36	36	10.7–11.2	15	10.8
Coef of Ther Exp (80–212 F), per °F	7.4×10^{-6}	7.4×10^{-6}	7.2×10^{-6}	7.8×10^{-6} [d]	7.8×10^{-6} [d]
Specific Heat (80–212 F), Btu/lb/°F	0.130	0.130	0.104	0.127 [d]	0.127 [d]
Elec Res (32 F), microhm-cm	9.5	8.3	46.5 (soft)	48.2 [e]	58.1 [e]
Magnetic?	Yes	Yes	Yes	Slightly	No to −150 F
MECHANICAL PROPERTIES [a]					
Mod of Elast in Tension, psi	30×10^6	30×10^6	30×10^6	26×10^6	26×10^6
Tensile Strength, 1000 psi					
Annealed	55–75	50–60	90–120	70–85	90–105
Annealed, Age Hardened	—	—	160–190	—	130–170
Spring	90–130	—	155–190	100–140	145–165
Spring, Age Hardened	—	—	180–230	—	170–200
Yield Strength, 1000 psi					
Annealed	15–30	12–25	35–60	25–45	40–65
Annealed, Age Hardened	—	—	—	—	90–120
Spring	70–115	—	—	90–130	130–160
Spring, Age Hardened	—	—	—	—	130–180
Elongation (in 2 in.), %					
Annealed	55–40	60–40	50–130	50–35	45–25
Annealed, Age Hardened	—	—	25–10	—	25–15
Spring	15–2	—	10–2	15–2	8–3
Spring, Age Hardened	—	—	15–5	—	10–5
Hardness (Rockwell)					
Annealed	B64 (max)	B55 (max)	B90 (max)	B68 (max)	B85 (max)
Annealed, Age Hardened	—	—	C30–40	—	C24 (min)
Spring	B95 (min)	—	C30–40	B98 (min)	C25 (min)
Spring, Age Hardened	—	—	C36–46	—	C34 (min)
Endurance Limit (10^8 cycles), 1000 psi					
Hot Rolled	33 [c]	33 [c]	51	—	—
Cold Drawn	50 [c]	50 [c]	51	—	—
THERMAL TREATMENTS					
Annealing Temperature, F	1500 (2–5 min)	1500 (3–6 min)	1600 (2–5 min)	1600–1800 (open), 1400–1500 (box)	1400–1800 (1–5 min)
Aging Temperature, F	—	—	1100 (8–16 hr)	—	1100 (8–16 hr, f.c.) [f]
FABRICATING PROPERTIES					
Hot Working Temp Range, F					
Heavy Forging, Drop Forging	1600–2300	1400–2300	1900–2300	1700–2150	1900–2150
Light Forging	1200–1600	1200–1600	1600–1900	—	—
Cutting Speed, fpm [b]	—	—	—	125–225	100–200
Joining	Metallic arc, inert-gas metal arc, oxy-acetylene and resistance welding; silver and copper brazing; soft soldering		Metallic arc, inert-gas metal arc and resistance welding; silver brazing; soft soldering	Metal arc, inert-gas metal arc, oxy-acetylene and resistance welding; silver and copper brazing; soft soldering	
AVAILABLE FORMS	Sheet, strip, rod, bar, shapes, tube, plate, wire		Strip, rod, bar, shapes, wire	Sheet, strip, rod, bar, shapes, tube, plate	
USES	Parts requiring corrosion resistance at high temperatures	Equipment handling molten salts; long time service at 700–1200 F	Parts requiring corrosion resistance and strength at high temperatures	Parts requiring combination of good strength, ductility and corrosion resistance	Parts requiring greater strength and hardness than monel

[a] Values are for sheet and strip unless otherwise specified.
[b] Surface speed with single point cemented carbide tools.
[c] Rod.
[d] 77–750 F.
[e] 68 F.
[f] Furnace cool.

Nickel and Its Alloys—Cast

Type →	Nickel	Inconel	S Inconel	Monel	S Monel
COMPOSITION, %	Ni 97.00, Cu 0.30, Fe 0.25, Si 1.50, Mn 0.50, C 0.50, S 0.015	Ni 78.00, Cu 0.25, Cr 13.00, Fe 6.00, Si 2.00, Mn 0.75, C 0.20, S 0.010	Ni 68.00, Cr 15.00, Fe 7.50, Si 5.50, Mn 0.75, C 0.30	Ni 67.00, Cu 29.00, Fe 1.25, Si 1.50, Mn 0.75, C 0.15	Ni 65.00, Cu 28.00, Fe 2.00, Si 4.00, Mn 0.75, C 0.10
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.301	0.300	0.292	0.312	0.302
Melting Temp Range, F	2450–2600	2500–2550	—	2400–2450	2300–2350
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	34.2	8.7	—	15.5	11.3
Coef of Ther Exp (70–1400 F), per °F	6.8×10^{-6}	8.92×10^{-6}	9.20×10^{-6}	6.8×10^{-6}	6.8×10^{-6}
Spec Ht (80–750 F), Btu/lb/°F	0.13	0.11	—	0.13	0.13
Elec Res (32 F), microhm-cm	20.8	11.6	12.6	53.2	65.3
Magnetic Trans Temp, F	680	−40	—	110–140	−70
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	21.5×10^6	23×10^6	25×10^6	19×10^6	24.2×10^6
Ten Str, 1000 psi					
Annealed and Aged	—	—	75–30	—	110–145
As Cast	45–60	70–95	90–120	65–90	110–145
Yld Str (0.5% ext), 1000 psi					
Annealed and Aged	—	—	55–70	—	80–115
As Cast	20–30	30–45	80–100	32–45	80–115
Elong (in 2 in.), %					
Annealed and Aged	—	—	4–1	—	1–4
As Cast	30–15	30–10	3–1	25–45	1–4
Hardness (Brinell)					
Annealed and Aged	—	—	300–380	—	300–380
As Cast	80–125	190	300–380	125–150	275–350
Impact Str (Charpy, rm temp), ft-lb	60	60	—	70	4
FABRICATING PROPERTIES					
Pouring Temp, F	2700–2900	2800–2950	2700–2900	2700–2850	2650–2800
Pattern Shrinkage, in./ft	0.25	0.25	0.25	0.25	0.25
Weldability	Fabrication or repair by any standard process*	Repair welding by any standard process*	Welding not recommended	Limited amount of repair welding*	Welding not recommended
CORROSION RESISTANCE	Good corrosion resistance, especially to hot concentrated caustic soda, and chlorine and fluorine gases	Resistance to nitric acid, ammonium hydroxide and oxidizing conditions superior to that of nickel. Good resistance to oxidation at temperatures up to 2200 F. Good resistance to corrosive vapors above 800 F		Good resistance to flowing salt water; dilute acids; hydrochloric, hydrofluoric, sulfuric, phosphoric and most organic acids; and strong caustic soda. Not resistant to strongly oxidizing solutions such as nitric acid and ferric chloride	
USES	Evaporators, tanks, heating coils, tubular condensers and other processing equipment; magnetostrictive devices; applications in incandescent lamp and radio industries	Dairy equipment, food handling equipment, airplane exhaust manifolds, utensils. Used extensively in oxidizing and carburizing atmospheres at elevated temperatures. Inconel S castings have higher resistance to wear and galling than Inconel		Valve seats, liners, pump rods, bushings, nozzles, turbine blading, pickling equipment, laundry machines, paper mill and oil refinery equipment, food handling equipment, storage tanks, boilers. Monel S castings have higher resistance to galling and erosion than Monel	

* For joining by welding, a weldable grade is available.

Low-Expansion Nickel Alloys—Wrought

Composition (%)* →	Ni 36	Ni 42	Ni 47-50
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.292	0.292	0.296
Melting Point, F	2600	2606	2600
Ther Cond (68–212 F), Btu/hr/sq ft/°F/ft	7.8	8.9	10.3
Coef of Ther Exp, per °F			
−200 to 0 F	1.10×10^{-6}	3.42×10^{-6}	5.37×10^{-6}
0 to 200 F	0.70×10^{-6}	3.18×10^{-6}	5.55×10^{-6}
200 to 400 F	1.50×10^{-6}	2.97×10^{-6}	5.55×10^{-6}
400 to 600 F	6.35×10^{-6}	3.15×10^{-6}	5.55×10^{-6}
600 to 800 F	8.61×10^{-6}	5.50×10^{-6}	5.60×10^{-6}
800 to 1000 F	9.48×10^{-6}	8.55×10^{-6}	7.26×10^{-6}
Specific Heat (77–212 F), Btu/lb/°F	0.123	0.121	0.120
Electrical Resistivity (68 F), microhm-cm	81	70	48
Poisson's Ratio	0.290	0.290	0.290
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	21×10^6	22×10^6	24×10^6
Tensile Strength, 1000 psi			
Annealed	71	68	77
Cold Worked	90	120	140
Yield Point, 1000 psi			
Annealed	40	39	33
Cold Worked	70	—	—
Elongation (in 2 in.), %			
Annealed	43	49	45
Cold Worked	20	—	—
Reduction of Area, %			
Annealed	75	79	75
Cold Worked	60	—	—
Hardness			
Annealed (Brinell)	132	138	144
Cold Worked (Rockwell)	—	B100	B103
Modulus of Rigidity, psi	8.1×10^6	8.5×10^6	9.3×10^6
FABRICATING PROPERTIES			
Annealing Temp, F	Soften progressively in range 1000 to 2300 F		
Hot Working Temp Range, F	To 2300 F	To 2300 F	To 2300 F
Machinability	Machine best at a hardness of about Rockwell C20		
Weldability	Can be welded by acetylene torch, metal arc, carbon arc and resistance methods		
CORROSION RESISTANCE	Resistant to atmospheric corrosion and to fresh and salt water		
AVAILABLE FORMS	Bar, plate, sheet, strip, wire, tubing, forgings, castings		
USES	Length standards, instruments, hypodermic syringes, textile machine parts, thermostatic bimetal — up to 400 F	Higher temperature thermostatic bimetal, instruments, glass sealing — up to 650 F	Higher temperature low expansion applications—up to 1000 F

*Balance iron.

Nickel-Base Superalloys

Type →	Inconel X[a]	Hastelloy B[b]	Hastelloy C[b]	Hastelloy X,[b] Unitemp HX	René-41, R-41[c]
COMPOSITION, %	Cu 0.05, Cr 15.0, Fe 7.0, Al 0.75, Si 0.40, Ti 2.50, Mn 0.50, C 0.05, S 0.007, Cb 0.90, Ni bal	Co 2.50, Cr 1.0, Mo 26.0–30.0, Fe 4.0–7.0, Si 1.0, Mn 1.0, C 0.05, Ni bal	Co 2.50, Cr 14.5–16.5, Mo 15.0–17.0, W 3.0–4.5, Fe 4.0–7.0, Si 1.0, Mn 1.0, C 0.08, Ni bal	Co 0.5–2.5, Cr 20.5–23.0, Mo 8.0–10.0, W 0.20–1.0, Fe 17.0–20.0, C 0.05–0.15, Si 1.0, Mn 1.0, Ni bal	Cr 18.0–20.0, Co 10.0–12.0, Mo 9.0–10.5, Fe 5.0, C 0.12, Si 0.5, Mn 0.1, Ti 3.0–3.3, Al 1.4–1.6, Ni bal
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.30	0.33	0.32	0.29	0.29
Melting Temp Range, F	2540–2600	2408–2462	2318–2381	2350	—
Ther Cond (1100 F), Btu/hr/sq ft/°F/ft	13.0	9.5	9.9	15.0	11.7
Coef of Ther Exp (70–1600 F), per °F	9.2×10^{-6}	7.8×10^{-6}	8.2×10^{-6}	9.0×10^{-6}	8.7×10^{-6}
Specific Ht (70–212 F), Btu/lb/°F	0.10	0.09	0.09	0.10	0.10
Elec Res (75 F), microhm-cm	122	135	139	118.3	—
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi					
Room Temp	31×10^6	29.5×10^6	30.9×10^6	28.0×10^6	31.8×10^6
1000 F	25×10^6	32.8×10^6	25.9×10^6	24.3×10^6	27.2×10^6
1500 F	18.5×10^6	22.3×10^6	22.2×10^6	—	24.2×10^6
Ten Str, 1000 psi					
Room Temp	162	131	130	114	205
1000 F	140	107	106	94	203
1500 F	52	53 (1600 F)	45 (1600 F)	52	135
1800 F	9	—	26.9	21	60 (1700 F)
Yld Str (0.2% offset), 1000 psi					
Room Temp	92	56.5	71.8	52.2	154
1000 F	84	41.6	53.6	41.5	147
1500 F	44	38.7 (1600 F)	36.5 (1600 F)	37	120
1800 F	5.5	—	—	17	50 (1700 F)
Elong (in 2 in.), %					
Room Temp	24	50	44	43	14
1000 F	22	38	27	45	14
1500 F	22	11 (1600 F)	47 (1600 F)	33.5	14
1800 F	89	—	37.6	39	26 (1700 F)
Hardness, Brinell					
Room Temp	209	209[d]	218[d]	187	—
1000 F	—	92[d]	84[d]	—	—
Impact Str (Izod), ft-lb					
−320	33	53[d]	27[d]	—	—
Room Temp	37	58–62[d]	21–23[d]	—	—
Rupture Str (1500 F), 1000 psi					
10 Hr	38	26[d]	26[d]	22[d]	65[d]
100 Hr	28	16[d]	18[d]	14.5[d]	45[d]
1000 Hr	18	10[d]	12.5[d]	—	29[d]
THERMAL TREATMENT					
Solution Temp, F	2100 (2–4 hr, a.c.)	2150 (a.c.)	2250 (w.q.)	2150 (w.q.)	1950 (4 hr, a.c.) or 2150 (2 hr, a.c.)
Aging Temp, F	1550 (24 hr, a.c.) or 1330 (20 hr, a.c.)	—	—	—	1650 (4 hr, a.c.) or 1400 (18 hr, a.c.)
FABRICATING PROPERTIES					
Hot Working Temp, F	2225–1900	2175–1800	2250–1850	2200–1800	2150–1850
Machinability Index[e]	15	12	10	—	—
Weldability	Satisfactory	Good	Good	Excellent	Good
AVAILABLE FORMS	Sheet, rod, bar, shapes, tube, plate, wire	Sheet, strip, plate, bar, wire, tubing, electrodes, forgings; sand and investment castings	Sheet, strip, plate, bar, wire, tubing, electrodes, forgings; sand and investment castings	Sheet, plate, bar, wire, electrodes, forgings; sand and investment castings	Sheet, strip, plate, bar, forgings, wire; investment castings
USES	Jet engines, missiles, furnaces, etc., where high temperature corrosion resistance is vital				

[a] Hot rolled bar heat treated as specified unless otherwise indicated.
[b] Sheet 0.109 in. thick heat treated as specified unless otherwise indicated.
[c] Bar solution treated 4 hr at 1950 F, air cooled, aged 16 hr at 1400 F unless otherwise indicated.
[d] Heat treated bar.
[e] Based on AISI B1112 steel = 100.

continued on next page

Nickel-Base Superalloys

Type →	Udimet 500	Udimet 700	Waspaloy	Nicrotung[a]	J-1500
COMPOSITION, %	C 0.15 (max), Al 2.5–3.2, Ti 2.5–3.2, Mo 3.0–5.0, Cr 15.0–20.0, Co 13.0–20.0, Fe 4.0, B 0.008 (max), Ni bal	C 0.15 (max), Al 3.75–4.75, Ti 3.0–4.0, Mo 4.5–5.7, Cr 13.0–17.0, Co 17.0–20.0, Fe 1.0, B 0.10 (max), Ni bal	C 0.10 (max), Al 1.3, Ti 3.00, Mo 4.25, Cr 19.50, Co 13.5, Fe 2.0, B 0.005, Zr 0.085, Mn 0.50 (max), Si 0.75 (max), S 0.030 (max), Cu 0.10 (max), Ni bal	C 0.10, B 0.05, Zr 0.05, Cr 12.0, Co 10.0, W 8.0, Al 4.0, Ti 4.0, Ni bal	C 0.15, Cr 20.0, Co 10.0, Mo 10.0, Ti 3.0, Al 1.0, Ni bal
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.29	0.28	0.29	0.30	0.29
Ther Cond (1600 F), Btu/hr/sq ft/°F/ft	14.1	—	14.6	—	12.4[e]
Coef of Ther Exp (1800 F), per °F	9.8×10^{-6}	—	9.7×10^{-6}	8.8×10^{-6}	7.7×10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	0.10–0.11	0.10–0.11	—	—
Elec Res (70–1800 F), microhm-cm	121.5–136.5	130–148	—	—	—
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi					
Room Temp	31.2×10^6	32.1×10^6	31.9×10^6	33.5×10^6	29.8×10^6
1500 F	23.3×10^6	23.5×10^6	24.1×10^6	25.7×10^{6b}	21.8×10^6
1800 F	20.6×10^6	—	21.1×10^6	—	—
Ten Str, 1000 psi					
Room Temp	175	205	180	130	180
1200 F	175	180	165	120	168
1500 F	125	130	100	115	106
1800 F	40	50	55 (1700 F)	67	74 (1600 F)
Yld Str (0.2% offset), 1000 psi					
Room Temp	110	140	120	120	122
1200 F	110	125	105	111	108
1500 F	90	110	90	102	93
1800 F	35	45	50 (1700 F)	52	70 (1600 F)
Elong (in 2 in.), %					
Room Temp	15	16	29	5	16
1200 F	18	15	23	11	11
1500 F	22	33	28	4	13
1800 F	22	27	36 (1700 F)	6	18 (1600 F)
Hardness, Rockwell					
Room Temp	C37	—	C37	C38–40	C38
800 F	C36	—	C35	—	C33
1000 F	C36	—	C35	—	—
1200 F	C32	—	C35	—	C33
Fatigue Str (10^7 cycles, 1500 F), 1000 psi	48	49	40	37[c]	50[f]
Rupture Str (1600 F), 1000 psi					
100 Hr	32	42	25	48	23
1000 Hr	21	29	15	36[d]	14
THERMAL TREATMENT					
Solution Temp, F	2150 (2 hr, a.c.) or 1975 (4 hr, a.c.)	2115 (2 hr, a.c.) or 1975 (4 hr, a.c.)	1975 (4 hr, a.c.)	—	2100 (4 hr, a.c.) or 1950 (4 hr, a.c.)
Aging Temp, F	1550 (24 hr, a.c.) or 1400 (16 hr, a.c.)	1550 (24 hr, a.c.) or 1400 (16 hr, a.c.)	1550 (24 hr, a.c.) or 1400 (16 hr, a.c.)	—	1400 (16 hr, a.c.)
FABRICATING PROPERTIES					
Hot Work Temp, F	1900–2175	1875–2050	1850–2150	Not workable	1700–2100
Machinability	Satisfactory	Satisfactory	Satisfactory	—	—
Weldability	Satisfactory	Satisfactory	Satisfactory	—	Good
OXIDATION RESISTANCE	Excellent	Good	Good	Good	Good
AVAILABLE FORMS	Bar, wire, billet, plate, sheet, strip			Casting alloy	Bar, plate, sheet, wire, forgings
USES	Jet engines, missiles, etc., where high temperature corrosion resistance is vital				

[a] Castings. [b] At 1600 F. [c] 10^5 cycles at 1700 F. [d] 500 hr. [e] From 70–1500 F. [f] 10^8 cycles.

Nickel-Base Superalloys

Type →	Unitemp 1753	M-252	Inconel 700	Inconel 713C [a]
COMPOSITION, %	C 0.24, Mn 0.05, Si 0.10, Cr 16.25, Co 7.20, Mo 1.60, W 8.40, Ti 3.15, Al 1.90, Zr 0.06, B 0.008, Fe 9.50, Ni bal	C 0.16, Mn 0.02, Si 0.08, Cr 19.10, Co 9.95, Mo 9.70, Ti 2.55, Al 1.10, Zr 0.06, B 0.005, Fe 2.10, Ni bal	C 0.16, Mn 0.10, Si 0.25, Cr 15.0, Ti 2.20, Al 3.0, Co 28.0, Mo 3.0, Fe 0.7, Ni bal	C 0.20 max, Mn 1.0 max, Si 1.0 max, Cr 12.5, Mo 4.25, Ti 0.75, Al 6.0, Fe 5.0 max, Cb 2.0, Ni bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.305	0.298	0.295	0.286
Melting Temp Range, F	2525–2575	2470–2500	—	—
Ther Cond (1500 F), Btu/hr/sq ft/°F/ft	—	12.4	10.3	—
Coef of Ther Exp (80–1600 F), °F	8.6×10^{-6}	7.8×10^{-6} [c]	9.27×10^{-6}	8.3×10^{-6}
Elec Res, microhm-cm	132.0	—	—	—
MECHANICAL PROPERTIES [b]				
Mod of Elast in Tension, psi				
Room Temp	31.0×10^6	29.8×10^6	32.0×10^6	—
1000 F	26.5×10^6	26.0×10^6	27.7×10^6	—
1500 F	22.8×10^6 [d]	21.8×10^6	24.0×10^6	—
Ten Str, 1000 psi				
Room Temp	177	175	170	117
1200 F	161	152	147	118
1600 F	79	71	84	98
Yld Str (0.2% offset), 1000 psi				
Room Temp	103	98	104	105
1200 F	99	92	92	105
1600 F	60 (1650 F)	71	56	80
Elongation (in 2 in.), %				
Room Temp	20.5	25.0	25.0	6.0
1200 F	24.0	35.5	23.0	5.0
1600 F	19.5	39.5	7.0	8.0
Red. of Area, %				
Room Temp	21.5	—	27.0	—
1200 F	23.2	27.0	37.0	—
1600 F	35.0	55.5	8.0	—
Fatigue Str (10^8 cycles), 1000 psi				
1300 F	58 (1350 F)	60	—	—
1500 F	48	50	—	—
Rupture Str (1500 F), 1000 psi				
10 Hr	60	48	55	70
100 Hr	47	38	42	56
1000 Hr	34	23	31	43
FABRICATING PROPERTIES				
Hot Working Temp, F	1850–2150	1800–2150	—	—
Machinability [e]	Poor	Poor	8	6
Weldability	Limited data	Limited data	Weldable	Rarely welded
CORROSION RESISTANCE	Excellent res to jet engine gases up to 1600 F; very good res to salt spray. Good oxidation res under continuous operation up to 1900 F		Good corrosion and oxidation resistance up to 1600 F	Excellent res to oxidation at 1700 F
AVAILABLE FORMS	Bar, billet, forgings, sheet, wire		Bar, forgings	Investment castings
USES	Jet engine turbine buckets, wheels; high temp bolts and fasteners; airframes		Aircraft engine blades and other high temp components	Aircraft gas turbine blades and vanes, and other high temp applications

[a] Casting alloy.

[b] Properties for materials in the following conditions:
Unitemp 1753: Bar solution treated 4 hr at 2150 F, air cooled, aged 16 hr at 1650 F, air cooled.
M–252: solution treated 4 hr at 1950 F, air cooled, aged 15 hr at 1400 F, air cooled.
Inconel 700: rod solution treated 2 hr at 2160 F, air cooled, aged 4 hr at 1600 F, air cooled.
Inconel 713C: as cast bar.

[c] Based on AISI B1112 steel = 100. [d] 1600 F. [e] 70–1500 F.

Precious Metals—Wrought

Metal →	Gold[a]	Silver[b]	Platinum[c]	Palladium[b]
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.698	0.379	0.775	0.434
Melting Point, F	1945	1761	3224	2829
Ther Cond (212 F), Btu/hr/sq ft/ °F/ft	172	242	42	41
Coef of Ther Exp (32–212 F), per °F	7.9×10^{-6}	10.9×10^{-6}	4.9×10^{-6}	6.5×10^{-6}[a]
Spec Ht, Btu/lb/°F	0.031	0.056	0.031	0.058
Elec Res (32 F), microhm-cm	2.35	1.59[d]	14.9	10.8[a]
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	12×10^6	11×10^6	21×10^6	17×10^6
Ten Str, 1000 psi				
Annealed	19	22	17–26	30
Cold Worked	32[e]	54[f]	34–45	47
As Cast	18	15	—	—
Yld Str, 1000 psi				
Annealed	Nil	8	2–5.5	5
Cold Worked	30	44	27	30
As Cast	—	5	—	—
Elong (in 2 in.), %				
Annealed	45	48	30–40	24–40
Cold Worked	4	2.5	2.5–3.5	1.5
As Cast	30	60	—	—
Red. of Area (as cast), %	—	67	—	—
Hardness (Brinell)				
Annealed	25	25–35	38–52	46
Cold Worked	58	—	97–13	109
As Cast	33	42	—	—
Endurance Limit (10^7 cycles, annealed), 1000 psi	4.6	—	—	—
FABRICATING PROPERTIES				
Annealing Temp, F	—	400–600	1475–2200	1475
Hot Working Temp Range, F	Any to melting point	—	1475–2300	1475–2300
Max Red. Between Anneals, %	Apparently unlimited	—	99	99
Casting Temp Range, F	2000–2370	2000	3300	3000
Joining	Braze with silver solder, no flux, any flame. Can be resistance welded by any method. Oxyacetylene weld with no flux, any flame	Braze with silver solder. Can be resistance welded	Braze with fine gold or white platinum solder. Hammer weld at 1800 F. Can be resistance or oxyacetylene welded	Braze with oxyacetylene torch using platinum solders. Can be resistance welded
CORROSION RESISTANCE	Does not oxidize when heated in air. Resists alkalis, salts and most acids. Not attacked by oxygen or sulfur. Rapidly attacked by chlorine and bromine	Does not oxidize when heated in air. Resists most dilute mineral acids and alkalis. Attacked rapidly by nitric and hot sulfuric acids. Attacked rapidly by sulfur-bearing gases	Does not oxidize when heated in air. Resists reducing or oxidizing acids alone but is dissolved by aqua regia	Oxidizes when heated in air. Resists hydrofluoric, acetic and phosphoric acids. Attacked by nitric, sulfuric and hydrochloric acids; and bromine and iodine
AVAILABLE FORMS	Foil, rod, wire, sheet, tubing	Sheet, strip, rod, wire, tubing	Foil, sheet, wire, tubing	Sheet, foil, wire, tubing
USES	Lining of chemical equipment, high melting solder, alloys for electrical and chemical purposes, jewelry, dentistry	Electrical contacts, corrosion resisting equipment, bearings, photography supplies; alloying for coinage, brazing alloys, jewelry	Chemical equipment, electrical contacts, catalysts, laboratory equipment, jewelry	Electrical contacts, catalysts, production of pure hydrogen, jewelry, dental alloys

[a]Gold is generally produced in three grades: proof gold, 99.99% Au; refined gold, 99.95-99.98% Au; and 99.5% Au, which is accepted by the U.S. Mint without penalty.
[b]Usually refined to "the high purity suitable for general use"; in some cases spectographically pure.
[c]Platinum is produced in four grades: type A, 99.99% Pt, sometimes called physically pure; type B, 99.9% Pt, sometimes called chemically pure; type C, 99.5% Pt (crucible grade); and type D, 99% Pt (commercial platinum).
[d]68 F. [e]Cold rolled, 60% reduction. [f]Cold rolled, 50% reduction.

Precious Metals—Cast, Wrought

Metal →	Rhodium[b]	Ruthenium[b]	Osmium[b]	Iridium[b]
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.447	0.441	0.82	0.813
Melting Point, F	3571	4530	4890	4450
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	50	—	—	34
Coef of Ther Exp (68 F), per °F	4.6×10^{-6}	5.1×10^{-6}	3.6×10^{-6}	3.8×10^{-6}
Specific Heat, Btu/lb/°F	0.059	0.057	0.031	0.031
Elec Res (68 F), microhm-cm	4.51	7.6[a]	9.5	5.3
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	42×10^6	60×10^6	80×10^6	74×10^6
Ten Str, 1000 psi				
Annealed	73	—	—	—
Cold Worked	300	—	—	—
Hardness (Brinell)				
Annealed	55–156	—	—	170
Cold Worked	260–390	—	—	350
As Cast	—	220	350	163
FABRICATING PROPERTIES				
Hot Working Temp Range, F	1900–2000	2700–4300	Not workable	2200–2700
Max Red. Between Anneals, %	30–40	—	—	—
Casting Temp, F	3700	4700	5000	4600
Joining	Can be brazed and resistance welded	Can be brazed and resistance welded	Can be brazed and resistance welded	Can be brazed and resistance welded
CORROSION RESISTANCE	Oxidizes slowly when heated in air. Resistant to most acids, including aqua regia at room temperature	Oxidizes when heated in air. Unattacked by common acids, including aqua regia up to 212 F. Moderately attacked by solutions of alkaline hypochlorites	Oxidizes rapidly in air at elevated temperatures. Resists common acids at room temperatures, but is attacked by aqua regia	Oxidizes slowly when heated in air. Unattacked by common acids, including aqua regia up to 212 F
AVAILABLE FORMS	Powder, sheet, wire	Powder	Cast or sintered parts	Sheet, wire, rod, powder
USES	Mirrors and electrodeposits for a nontarnishing finish; alloys with platinum and palladium for crucibles, glassworking equipment, catalysts, spinnerets	Hardener for platinum and palladium	Alloys used for pen tips, phonograph needles, electrical contacts, instrument pivots	Extrusion dies for glass, alloys with platinum for electrical contacts, fuse wires, hypodermic needles, jewelry

[b]Usually refined to "the high purity suitable for general use"; in some cases spectrographically pure.
[a]At 32 F.

Tin and Its Alloys—Cast, Wrought

Type →	Grade A Tin	Hard Tin	Tin Foil	White Metal	Pewter
COMPOSITION, %	Sn 99.8 min	Sn 99.6, Cu 0.4	Sn 92, Zn 8	Sn 92, Sb 8	Sn 91, Sb 7, Cu 2
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.264	—	—	0.262	0.263
Melting Temp Range, F	449.4	441–446	390	475	471–563
Ther Cond (77 F), Btu/hr/sq ft/°F/ft	37	—	34	—	—
Coef of Ther Exp (32–212 F), per °F	13 x 10[a]	—	—	—	—
Spec Ht, Btu/lb/°F	0.054	—	—	—	—
Elec Res (68 F), microhm-cm	11.5	—	12	15	—
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	6–6.5 x 10[6]	—	—	—	7.7 x 10[6]
Ten Str, 1000 psi					
Annealed Sheet	2.2	3.3	—	6.7	8.6
Cold Rolled Sheet	2.8	4.0	8.7	7.4[b]	7.6
As Cast	2.1	—	—	7.2[c]	—
Yld Str, 1000 psi					
Annealed Sheet	1.3	—	—	—	—
Cold Rolled Sheet	2.0	—	6.0	—	—
As Cast	1.7	—	—	—	—
Elong (in 2 in.), %					
Annealed Sheet	45	—	—	70	40
Cold Rolled Sheet	35	—	40	28[b]	50
As Cast	55[a]	—	—	—	—
Hardness (Brinell)					
Annealed Sheet	7	—	—	17	13[d, f]
Cold Rolled Sheet	8	—	—	—	18[e, f]
As Cast	5–6	—	—	20[c]	23[d, f]
Impact Str (Izod, as cast), ft-lb	14	—	—	22[c]	—
Endurance Limit (as cast), 1000 psi	0.34	—	—	—	—
FABRICATING PROPERTIES					
Casting Temp Range (chill), F	525–550	525–550	—	575–600	600–625
Joining	Bonds easily by simple melting. Eutectic tin-lead solder or low melting fusible alloys might be used on massive parts such as block tin pipe		—	Readily soldered	Can be soldered with some of the fusible alloys
CORROSION RESISTANCE	Resists distilled, sea and soft tap water. Attacked by strong acids, alkalis and acid salts. Oxygen in solution accelerates rate of attack		—	—	Tarnishes in soft water; suffers localized attack at water line in hard water. Attacked by dilute hydrochloric and citric acids in presence of air
AVAILABLE FORMS	Sheet, pipe, foil, castings, powder	Tubing, foil	Foil	Castings, sheet	Castings, sheet
USES	Linings for food cans; pipe for handling water, beer, and carbonated beverages; linings for food processing equipment, food wrappings	Collapsible tubes, foil	Foil for wrapping food, medicines, electrical condensers	Rubber mold castings, cast and wrought costume jewelry	Mountings and ornamental objects such as tea and coffee services, vases and book ends

[a] In 4 in.
[b] Sheet quenched from 425 F.
[c] Chill cast.
[d] Vickers pyramid hardness.
[e] Vickers pyramid hardness after heat treating 3 hr at 300 F.
[f] Hardenable pewter values are: 13, 28, 29, respectively.

Tin-Lead-Antimony Alloys—Cast

Grade[a] ➡	1[b]	2	3	4	5[c]
COMPOSITION, %	Sn 91, Sb 4.5, Cu 4.5	Sn 89, Sb 7.5, Cu 3.5	Sn 84, Sb 8, Cu 8	Sn 75, Pb 10, Sb 12, Cu 3	Sn 65, Pb 18, Sb 15, Cu 2
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.265	0.267	0.269	0.272	0.280
Melting Temp Range, F	433–700	466–669	464–792	363–583	358–565
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	7.3×10^6	7.6×10^6	—	—	—
Ten Str, 1000 psi					
Chill Cast	9.3	11	10–12	—	—
Die Cast	10.3	—	—	—	11.8
Elong (in 2 in., die cast), %	22	—	—	—	4
Hardness (Brinell)					
Chill Cast	17	24	27	25	22
Die Cast	—	—	—	—	27.7
Impact Str (Izod, chill cast), ft-lb	2.5	—	1	—	—
Endur Limit (chill cast), 1000 psi	3.8[d]	4.8[d]	—	—	—
Compr Str (chill cast, 25% set), 1000 psi	13	15	18	16	15
Compr Yld Str (chill cast, 0.125% set), 1000 psi	4.4	6.1	6.6	5.5	5.0
FABRICATING PROPERTIES					
Casting Temp Range (chill), F	750–825	795	850–915	710	690–700
CORROSION RESISTANCE	Resists oxidation products of lubricants; food products, beer and carbonated beverages	Resist oxidation products of lubricants			
AVAILABLE FORMS	Precision inserts of babbitt-lined strip, lined bearing shells, ingots, die castings			Ingots	Ingots, die castings
USES	Bearings, die castings for dairy machinery, dental appliances, surgical instruments, soda fountain equipment	Most widely used tin-base bearing alloy in automotive field	High load applications, hardest of standard tin babbitts and has greatest load carrying capacity	Limited bearing applications	Limited bearing applications Die cast parts

[a] ASTM B23–49.
[b] Also die casting Alloy 1, ASTM B102-48.
[c] Also die casting Alloy 3, ASTM B102-48.
[d] 2×10^8 cycles.

continued on next page

Tin-Lead-Antimony Alloys—Cast

Grade[a] →	6	7	8	10	11
COMPOSITION, %	Sn 20, Sb 15, Pb 63.5, Cu 1.5	Sn 10, Sb 15, Pb 75	Sn 5, Sb 15, Pb 80	Sn 2, Sb 15, Pb 83	Sb 15, Pb 85
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.336	0.350	0.361	0.362	0.370
Melting Temp Range, F	358-531	464-514	459-522	468-507	471-504
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	—	14	14	—	—
Coef of Ther Exp (68-212 F), per °F	—	10.9×10^{-6}	13×10^{-6}	—	—
Spec Ht, Btu/lb/°F	—	0.065	0.065	—	—
Elec Res (68 F), microhm-cm	—	28.6	28.2	—	—
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	—	4.2×10^6	4.2×10^6	—	—
Ten Str, 1000 psi[e]	—	10.5	10	—	6.8
Elong (in 2 in.), %[e]	—	4	5	—	8
Hardness (Brinell)[e]	21	22	20	18	15
Endurance Limit, 1000 psi[e]	—	4[d]	3.9[d]	—	—
Compr Str (25% deformation), 1000 psi[e]	14.5	15.6	15.6	15.4	12.8
Compr Yld Str (0.125% set), 1000 psi[e]	3.8	3.6	3.4	3.4	3.0
FABRICATING PROPERTIES					
Casting Temp (chill), F	655	640	645	630	630
CORROSION RESISTANCE	Resistant to corrosion by the usual lubricants				
AVAILABLE FORMS	Small ingots and bars				
USES[f]	General purpose bearing applications	General purpose bearings under moderate loads	Bearings for light loads and moderate speeds. Mining machinery, transmission machinery, car journals	Bearings for light loads and speeds. Blowers, pumps, electric motors, machine tools	Bearings for light loads

[a] ASTM B23-49.
[d] 2×10^7 cycles.
[e] Chill cast.
[f] Light loads—under 1000 psi; moderate loads—1000 to 2000 psi; heavy loads—over 3000 psi. Surface speeds: low—to 10 fps; moderate—to 20 fps; high—above 30 fps.

Tin-Lead-Antimony Alloys—Cast

Grade[a] →	12	15	16	19
COMPOSITION, %	Sb 10, Pb 90	Sn 1, Sb 15, Cu 0.5, As 1.0, Pb bal	Sn 10, Sb 12.5, Cu 0.5, Pb bal	Sn 5, Sb 9, Pb bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.384	0.362	0.355	0.378
Melting Temp Range, F	473-498	479-538	471-495	462-495
Coef of Ther Exp (68-212 F), per °F	14.6×10^{-6}	—	—	—
Specific Heat, Btu/lb/°F	0.065	—	—	0.065
Elec Res (68 F), microhm-cm	25.6	—	—	28.7
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	—	4.2×10^6	—	4.2×10^6
Tensile Strength, 1000 psi[c]	—	10.4	—	10
Elongation (in 2 in.), %[c]	—	2	—	5
Hardness (Brinell)[c]	14	21	28	18
Endurance Limit, 1000 psi[c]	—	4.3[d]	—	3.7[f]
Compressive Strength (25% deformation), 1000 psi[c]	12.9	—	—	15.6
Compressive Yield Strength (0.125% set), 1000 psi[c]	2.8	—	—	—
FABRICATING PROPERTIES				
Casting Temp (chill), F	625	660	620	620
CORROSION RESISTANCE	Resistant to corrosion by the usual lubricants			
AVAILABLE FORMS	Small ingots and bars			
USES[f]	Bearings for light loads	Bearings for high loads and speeds. Diesel engines, automotive engines, steamships, various types of machines	Bearings for moderate loads and speeds	Bearings for light loads and speeds. Car journal bearings

[a] ASTM B23-49.
[c] Chill cast.
[f] Light loads—under 1000 psi; moderate loads—1000 to 2000 psi; heavy loads—over 3000 psi. Surface speeds: low—to 10 fps; moderate—to 20 fps; high—above 30 fps. 2×10^7 cycles.

Titanium and Its Alloys—Wrought

Type →	Unalloyed	5 Al-2.5 Sn	8 Mn	3 Mn-1.5 Al	4 Mn-4 Al
COMPOSITION, %	Ti 99.0	Al 5.0, Sn 2.5	Mn 8.0	Al 1.5, Mn 3.0	Al 4.0, Mn 4.0
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.163	0.161	0.171	0.168	0.163
Melting Temp Range, F	3135	2822–3002	2730–2970	—	2822–3002
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	9.8	4.85	6.7	—	4.5
Coef of Ther Exp (68–1650 F), per °F	5.8×10^{-6}	5.7×10^{-6}	7.1×10^{-6}	—	5.7×10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.125	0.127	0.118	—	0.129
Elec Res (68 F), microhm-cm	55.0	157.3	90.7	—	146.1
Magnetic Permeability (20 oersteds)	1.00005	1.00005	1.00005	—	1.00005
MECHANICAL PROPERTIES[a]					
Mod of Elast in Tension, psi	$15–16 \times 10^6$	$16–17.5 \times 10^6$	$15.5–17.5 \times 10^6$	15×10^6	$15.5–17.5 \times 10^6$
Ten Str, 1000 psi	80–110	115–145	120–150	125	140–170
Yld Str, 1000 psi	70–95	110–135	110–140	116	130–160
Elong (in 2 in.), %	15–25	10–20	10–20	18	10–20
Red. of Area, %	30–45	20–40	20–40	—	20–40
Hardness (Rockwell)	—	C30–35	C28–34	C26–32	C32–38
Impact Str (Charpy), ft-lb	20–35	15–25	—	15–20	11–15
Endurance Limit, 1000 psi					
Sheet (unnotched)	60–70	95	90	—	—
Bar (unnotched)	60–70	—	—	—	85–95
Bar (notched)	35–45	—	—	—	32[f]
Compr Yld Str, 1000 psi	75–100	115–140	115–145	—	—
Mod of Rigidity, psi	5.6×10^6	—	6×10^6	—	6.27×10^6
THERMAL TREATMENT					
Annealing Temp, F	850–1250	1500–1600	1300	1250	1300
Stress Relieving Temp, F	700–1000	1000–1200	<700 or at 1000	—	1000
FABRICATING PROPERTIES					
Hot Working Temp Range, F	300–800	800–1200	500–600	—	—
Forging Temp, F	1300–1600	1400–1900	—	1300–1700	1300–1750
Fusion Weldability[d]	Yes	Yes	No	Marginable	Questionable
Formability (sheet, 78 F)[e]	High	Intermediate	Good	Moderate	Bar only
Bend Radius (105° V)	3T	4.5T	3.5T	—	—
CORROSION RESISTANCE	Superior resistance to nitric acid, moist chlorine, chlorine solutions, chlorinated organic compounds, and inorganic chloride solutions. Excellent resistance to corrosive attack by sea water and most chloride salt solutions—unchallenged by other structural metals. Resists impingement, pitting attack				
AVAILABLE FORMS	Sheet, strip, plate, tubing, billets, bar, wire	Sheet, strip, plate, wire, bar	Sheet, strip, plate	Sheet, plate, billets, bar, wire	Billets, bar, forgings, plate, wire
USES	Aircraft and missile parts requiring corrosion resistance and high strength-to-weight ratio up to 800 F. Naval and marine applications; chemical, pharmaceutical and food processing and handling equipment; marine diesel engine mufflers; springs (high proportional limit and low modulus of elasticity), rivets, bolts, nuts, screws and fittings; ordnance and sporting equipment; orthopedic and orthodontic equipment; anodes				

[a] Annealed condition unless otherwise stated.
[d] Some users report difficulty in producing welds without porosity; others do not.
[e] All titanium sheet is formed with considerably less difficulty at elevated temperatures. Forming can be accomplished at temperatures in the 500 to 1000 F range with no need for postforming surface treatment, provided time at temperature is short.
[f] k = 3.9

Titanium and Its Alloys—Wrought

Type →	7 Al–4 Mo	16 V–2.5 Al	4 Al–3 Mo–1 V	13 V–11 Cr–3 Al	6 Al–4 V
COMPOSITION, %	Al 7.0, Mo 4.0	V 16.0, Al 2.5	Al 4.0, Mo 3.0, V 1.0	V 13.0, Cr 11.0, Al 3.0	Al 5.5–6.3, V 3.5–4.5
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.162	0.168	0.161	0.175	0.160
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	—	—	—	4.3	4.3
Coef of Ther Exp (68–1650 F), per °F	4.9 x 10^{-6} [f]	—	—	5.2 x 10^{-6} [f]	5.8 x 10^{-6}
Spec Ht (212 F), Btu/lb/°F	0.123(68 F)	—	—	0.128	0.135
Elec Res (68 F), microhm-cm	175	—	—	—	176
MECHANICAL PROPERTIES[a]					
Mod of Elast in Tension (200 F), psi	15.5–17.5 x 10^6	15 x 10^6	—	13–15 x 10^6	15–17 x 10^6
Ten Str (68 F), 1000 psi					
Annealed	145–170	110–115	140	125–150	130–155
Heat Treated	160–200	175–180	190	190–240	170
Yld Str (68 F), 1000 psi					
Annealed	135–160	40–55	90	120–145	120–150
Heat Treated	150–190	160–165	168	170–220	150
Elong (in 2 in.), %					
Annealed (68 F)	10–18	15–20	16	10–20	10–20
Heat Treated	5–12	6–10	8	3–10	7–12
Red. of Area (68 F), %					
Annealed	20–40	65	—	20–40	25–40
Heat Treated	10–25	35	—	—	20–35
Hardness (Rockwell)					
Annealed	32–38	—	—	—	C30–36
Heat Treated	—	—	—	—	—
Impact Str (Charpy, 68 F), ft-lb	10–20	—	—	—	15–25
Endurance Limit (10^8 cycles), 1000 psi					
Bar (unnotched)	93	—	—	—	75
Bar (notched)	29	—	—	—	30
Sheet (notched)	—	—	—	34	—
Shear Str, 1000 psi	104–115	—	—	—	—
THERMAL TREATMENT					
Annealing Temp, F	1450–1650	—	1500–1675	1450	1350
FABRICATING PROPERTIES					
Hot Working Temp Range, F	—	—	—	200–400	—
Forging Temp, F	1400–1850	—	—	—	1450–1750
Fusion Weldability[d]	No	—	Limited	Yes	Marginal
Formability (sheet, 78 F)[e]	—	High	High	High	Intermediate
Bend Radius (105° V)	—	—	3.5T	3.5T	5.0T
CORROSION RESISTANCE	Superior resistance to nitric acid, moist chlorine, chlorine solutions, chlorinated organic compounds and inorganic chloride solutions. Excellent resistance to sea water and most chloride salt solutions unchallenged by other structural metals. Resist impingement, pitting attack				
AVAILABLE FORMS	Bar, rod, forgings, plate, wire, billet	Sheet, bar	Sheet, strip, plate	Sheet, strip, wire, bar, billet	Bar, sheet, strip, billet, plate, wire
USES	Aircraft and missile parts requiring corrosion resistance and high strength-to-weight ratio up to 800 F. Naval and marine applications; chemical, pharmaceutical and food processing and handling equipment; marine diesel engine mufflers; springs (high proportional limit and low modulus of elasticity), rivets, bolts, nuts, screws and fittings; ordnance and sporting equipment; orthopedic and orthodontic equipment; anodes				

[a] Annealed condition unless otherwise stated. [b] 60-deg notch, 0.010-in. radius, k = 2.7. [c] k = 4.0.
[d] Some users report difficulty in producing welds without porosity; others do not.
[e] All titanium sheet is formed with considerably less difficulty at elevated temperatures. Forming can be accomplished at temperatures in the 500 to 1000 F range with no need for postforming surface treatment, provided time at temperature is short.
[f] 68-200 F.

Zinc Alloys—Wrought

Type →	Commercial Rolled Zinc (deep drawing)	Commercial Rolled Zinc	Commercial Rolled Zinc (higher Pb, Cd)	Copper Hardened Rolled Zinc Alloy	Rolled Zinc Alloy (Cu, Mg)	Rolled Zinc Alloy (Cu, Ti)
COMPOSITION, %	Pb 0.10 max, Zn bal	Pb 0.05–0.10, Cd 0.05–0.08, Zn bal	Pb 0.25–0.50, Cd 0.25–0.45, Zn bal	Cu 0.85–1.25, Zn bal	Cu 0.85–1.25, Mg 0.006–0.016, Zn bal	Cu 0.50–1.5, Ti 0.12–0.50, Zn bal
PHYSICAL PROPERTIES						
Density, lb/cu in.	0.258	0.258	0.258	0.259	0.259	0.259
Melting Point, F	786	786	786	792	792	792
Ther Cond (64 F), Btu/hr/sq ft/°F/ft	62.2	62.2	—	—	60.5	60.5
Coef of Ther Exp, per °F						
With Grain	18.1×10^{-6}	18.1×10^{-6}	18.8×10^{-6}	—	19.3×10^{-6}	13.8×10^{-6}
Across Grain	12.8×10^{-6}	12.8×10^{-6}	13.0×10^{-6}	—	11.7×10^{-6}	10.8×10^{-6}
Spec Ht (68–212 F), Btu/lb/°F	0.094	0.094	0.094	0.0957	0.0957	0.0957
Elec Res (68 F), microhm-cm						
Hot Rolled	6.06	—	—	6.22	6.31	6.24
Cold Rolled	6.10	—	—	—	—	—
MECHANICAL PROPERTIES[a]						
Ten Str, 1000 psi						
Hot Rolled	19.5, 23	21, 25	23, 29	24, 30	29, 40	32, 42
Cold Rolled	21, 27	22, 29	25, 31	31, 40	36, 46	29, 37
Elong (in 2 in.), %						
Hot Rolled	65, 50	52, 30	50, 32	50, 35	20, 10	38, 21
Cold Rolled	50, 40	40, 30	45, 28	44, 30	25, 10	44, 60
Hardness (Brinell)						
Hot Rolled	38	43	47	52	61	—
Endurance Limit (hot rolled), 1000 psi	2.5	3.8	4.1	6.1	6.8	—
Creep Rate (12,000 psi, 77 F), days/%						
Hot Rolled	—	—	—	0.15	—	115.0
FABRICATING PROPERTIES						
Hot Working Temp Range, F	248–527	248–527	248–437	447–572	447–572	382–572
Melting Range, F	887–977	887–977	887–977	887–977	887–977	887–977
Ingot Casting Range, F	815–905	815–905	815–905	815–905	815–905	815–905
Annealing Temp, F	—	—	221	347	347	482
Machinability	Good	Good	Good	Good	Good	Good
Joining						
Torch Welding	Poor to fair	Poor to fair	Poor to fair	Poor to fair	Poor to fair	Good
Single Impulse Resistance Welding	Poor	Poor	Poor	Poor	Poor	Good
Multiple Impulse Resistance Welding	Fair to good	Fair to good	Fair to good	Fair to good	Fair to good	Good
Soldering	Good	Good	Good	Good	Good	Good
Common Processes	Drawing, bending, roll forming, stamping, swaging, coining, extruding					
	Impact extrusion					
	Spinning					
CORROSION RESISTANCE	Excellent resistance to both metropolitan and rural atmospheric corrosion (penetration in in. per yr is 0.000064 in Palmerton, Pa., and 0.00028 in New York City); also hot soapy water, printing inks, trichloroethylene, carbon tetrachloride, dry illuminating gas, and moisture- and acid-free hydrocarbons. Fair resistance to pure ethyl and methyl alcohols, glycerine, water, petroleum products. Poor resistance to steam, spray insecticides, animal oils, strong acids and bases, and mixtures of glycerine or alcohol and water					
AVAILABLE FORMS	Rolled plate, strip and sheet; extruded rod and shapes; drawn rod and wire					
USES	Dry batteries, eyelets and grommets, address plates, flashing, weatherstrip, laundry tags, novelties, lithoplates, condenser cans, embossing tape, leaders and gutters, corrugated roofing					
	Parts requiring no rigidity	Parts requiring some rigidity	Parts requiring maximum rigidity	Parts requiring maximum rigidity and some creep resistance	Parts requiring maximum rigidity and creep strength; low thermal expansion; resistance to grain growth	

[a] Two values represent properties parallel to grain and perpendicular to grain, in that order.

Zinc Alloys—Cast

Type →	Alloy XXIII[a]	Alloy XXV[a]	Slush Casting Alloy[b]	Slush Casting Alloy (unbreakable metal)[b]
COMPOSITION, %	Al 3.5–4.3, Mg 0.03–0.08, Zn[c] bal	Al 3.5–4.3, Cu 0.75–1.25, Mg 0.03–0.08, Zn[c] bal	Al 4.5–5.0, Cu 0.2–0.3, Zn[c] bal	Al 5.25–5.75, Zn[c] bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.24	0.24	—	—
Melting Point, F	728	727	734	743
Ther Cond (158–284 F), Btu/hr/sq ft/°F/ft	65.3	62.9	—	—
Coef of Ther Exp (68–212 F), per °F	15.2×10^{-6}	15.2×10^{-6}	—	—
Spec Ht (68–212 F), Btu/lb/°F	0.10	0.10	—	—
Elec Res (68 F), microhm-cm	6.37	6.54	—	—
MECHANICAL PROPERTIES[d]				
Ten Str, 1000 psi				
Die Cast	41	47.6	—	—
Chill Cast	—	—	28.0	25.0
Elong (in 2 in.), %				
Die Cast	10	7	—	—
Chill Cast	—	—	—	1
Hardness (Brinell, die cast)	82	91	—	—
Impact Str (Charpy), ft-lb				
Die Cast	43	48	—	—
Chill Cast	—	—	3	1
Endurance Limit (10^8 cycles, die cast), 1000 psi	6.9	8.2	—	—
Compr Yld Str (die cast), 1000 psi	60	87	—	—
Shear Str (die cast), 1000 psi	31	38	—	—
FABRICATING PROPERTIES				
Melting Temp Range, F	728–932	727–932	—	—
Die Casting Temp Range, F	740–800	740–800	—	—
Solidification Shrinkage, %	1.17	1.17	—	—
Machinability	Good	Good	Good	Good
Joining				
Torch Welding	Poor to fair	Poor to fair	—	—
Single Impulse Resistance Welding	Poor	Poor	—	—
Multiple Impulse Resistance Welding	Fair to good	Fair to good	—	—
Soldering	Poor[e]	Poor[e]	—	—
Common Fabrication Processes	Welding, soldering, machining, riveting, spinning, cold swaging		Welding, soldering, machining	
CORROSION RESISTANCE	Excellent resistance to both metropolitan and rural atmospheric corrosion[f]; also hot soapy water, printing inks, trichloroethylene, carbon tetrachloride, dry illuminating gas, and moisture- and acid-free hydrocarbons. Fair resistance to pure ethyl and methyl alcohols, glycerine, water and petroleum products. Poor resistance to steam, spray insecticides, animal oils, strong acids and bases, and mixtures of glycerine or alcohol and water			
USES	Automotive parts, household utensils, office equipment, building hardware, padlocks, toys, novelties, drop hammer dies (XXV)		Slush and permanent mold castings, principally for lighting fixtures	

[a] ASTM B86-57T.
[b] Because of their limited use, few data are available on these alloys.
[c] Special high grade zinc is required.
[d] Based on a ¼-in. section for die cast alloys; a ½-in. section for chill cast alloys.
[e] Cadmium-zinc and lead-tin solders diffuse into the casting, promoting subsurface attack. Castings must be nickel plated to be joined by lead-tin solders.
[f] Penetration in in. per yr in Palmerton, Pa., and New York City, respectively, is 0.78×10^{-4} and 2.2×10^{-4} for XXIII, and 0.63×10^{-4} and 2.8×10^{-4} for XXV.

Hafnium, Thorium, Uranium, Vanadium, Beryllium—Wrought

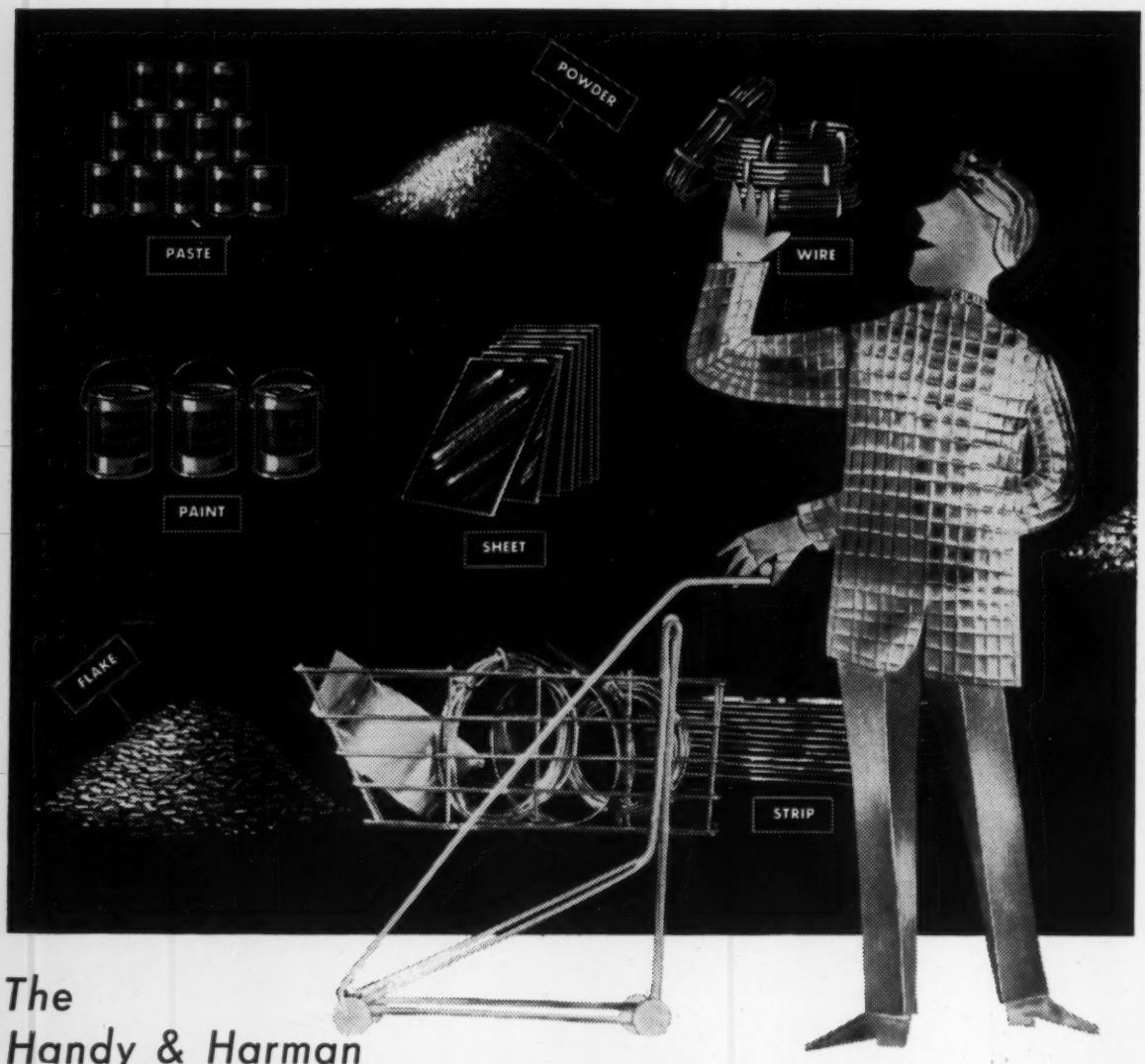
Metal →	Hafnium	Thorium	Uranium	Vanadium	Beryllium
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.47	0.42	0.69	0.23	0 067
Melting Point, F	3400	3180	2071	3110	2341
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	—	21.4[c]	14.5[c]	—	87
Coef of Ther Exp (70 F), per °F	3.4×10^{-6}	6.2×10^{-6}	12.1×10^{-6}[c]	4.8×10^{-6}	6.4×10^{-6}
Spec Ht, Btu/lb/°F	0.035	0.03	0.03	0.12	0.45
Elec Res (68 F), microhm-cm	30[a]	18	25–50	25	5
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	20×10^6	10×10^6	30×10^6	20×10^6	44×10^6
Ten Str, 1000 psi					
Annealed	77	34	90	72	60–90[f]
Cold Worked	112[b]	49[d]	—	11	—
Yld Str, 1000 psi					
Annealed	32	26	25	64	45–55[f]
Cold Worked	96[b]	45[d]	—	109	—
Elong (in 2 in.), %					
Annealed	24	51	13	28	2–5[f]
Cold Worked	10[b]	—	—	3	—
Hardness (Rockwell)					
Annealed	A58	—	—	B81	—
Cold Worked	A65[b]	—	—	B93	—
FABRICATING PROPERTIES					
Annealing Temperature, F	1380 in vacuum or inert atm	1380 in vacuum	—	1650 in vacuum or inert atm	1400–2100 in vacuum[g]
Workability	Can be hot worked at 1550 F; cold worked 30% between anneals	Can be readily hot or cold worked; fabricated by forging, rolling, swaging, extruding or drawing	Can be forged, rolled, swaged and drawn; heating must be done in a protective atm	Good cold working properties	Hot worked at 750–1800 F
Machinability	Similar to stainless steel	Can be machined like mild steel with or without cutting fluids	Moderately difficult to machine	Tools similar to those for cold rolled steel	Difficult because of low ductility
Joining	—	Difficult to weld; brazing yields brittle joints	Can be welded or brazed in protective atm or vacuum	Can be welded with heliarc torch under argon	Brazed with aluminum alloy or silver alloy rods
CORROSION RESISTANCE	Resistant to oxidizing acids but attacked by hydrofluoric acid	Very poor resistance to atmosphere, water and most reagents	Very poor resistance to atmosphere, water and most reagents	Resists sea water; not affected by moderate strength hydrochloric and sulfuric acids; dissolved by any strength nitric acid	Resists atm at ambient temp; attacked by oxygen and nitrogen at elevated temp; resists sea water; attack in fresh water varies with air content
AVAILABLE FORMS	Has been produced in sheet and rod	Has been produced in rod, sheet, thin-walled tube, fine wire, foil	Has been produced in plate, rod, tube, wire and foil	Plate, strip, bar, sheet, wire	Sheet, plate, rod, bar, tube, powder
USES	Nuclear reactors	Secondary (breeder) reactor fuel	Fissionable material (fuel) in nuclear reactor	AEC applications	Nuclear reactors, missiles, aircraft

[a] 32 F. [b] 20% cold work. [c] 70 F. [d] 50% cold work. [e] 70–250 F, parallel to A axis; 0.8×10^{-6} parallel to B axis; 12.9×10^{-6} parallel to C axis. [f] Warm extruded and annealed at 1400 F. Mechanical properties greatly influenced by method of fabrication. [g] Depends on form.

Zirconium and Its Alloys

Metal →	Zirconium	Zircaloy-2
COMPOSITION, %		Sn 1.2–1.7, Fe 0.07–0.17, Cr 0.05–0.15, Ni 0.03–0.08
PHYSICAL PROPERTIES		
Density, lb/cu in.	0.24	0.237
Melting Point, F	3355	3300
Thermal Conductivity (212 F), Btu/hr/sq ft/°F/ft	9.6	8.1
Coefficient of Thermal Expansion (70 F) per °F	3.1×10^{-6}	3.6×10^{-6}
Specific Heat, Btu/lb/°F	0.069	—
Electrical Resistivity (68 F), microhm-cm	40	74
MECHANICAL PROPERTIES		
Modulus of Elasticity in Tension, psi	14×10^6	13.8×10^6
Tensile Strength, 1000 psi		
Annealed	29[a], 59[b]	67
Cold Worked	82[a], 90[b]	108[c]
Yield Strength, 1000 psi		
Annealed	11[a], 38[b]	45
Cold Worked	58[a], 84[b]	98[c]
Elongation (in 2 in.), %		
Annealed	26[a], 27[b]	22
Cold Worked	1.5[a], 10[b]	6[c]
Hardness (Rockwell)		
Annealed	B42[a], B91[b]	B89.5
Cold Worked	B87[a], B98[b]	B96.5[c]
FABRICATING PROPERTIES		
Annealing Temperature, F	1550; heavy sections in air, light sections in vacuum or inert atm	1550 in vacuum
Workability	Similar to titanium	Hot worked at 1500–1800 F
Joining	Can be arc or flash-butt welded under inert atm	Can be brazed with special 4–5% Beryllium-Zircaloy 2 rod; can be welded
CORROSION RESISTANCE	Excellent resistance to hydrochloric acid in all concentrations. Resists dilute sulfuric acid, nitric acid in all concentrations, and alkalis. Attacked by aqua regia	
AVAILABLE FORMS	Sheet, rod, tubing, shapes	Billet bar, sheet, wire, tube
USES	Structural parts and fuel cladding in nuclear reactors. Probable future use: corrosion resisting equipment	

[a] Iodide zirconium; cold worked values are for 90% cold worked.
[b] Kroll zirconium, melted in graphite; cold worked values are for 60% cold worked.
[c] 40% cold work



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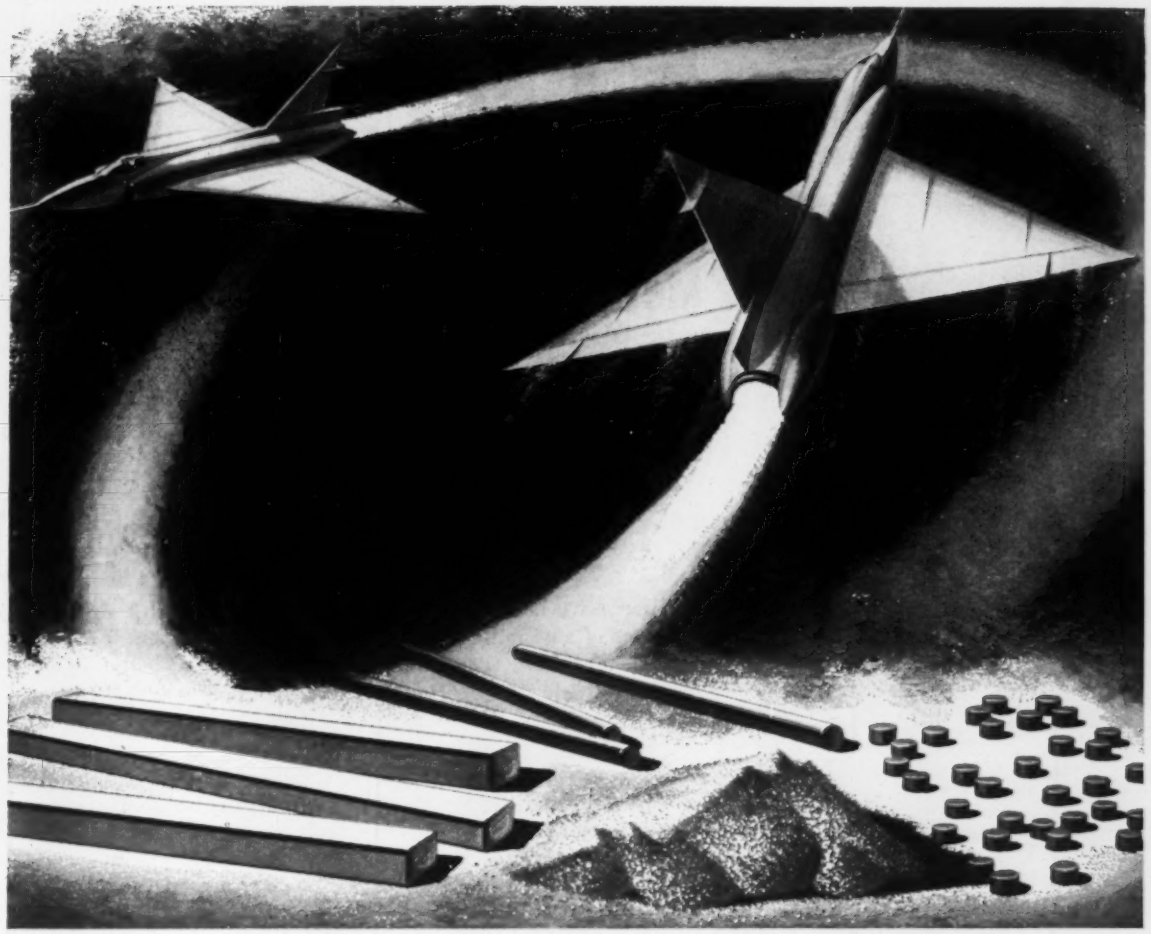

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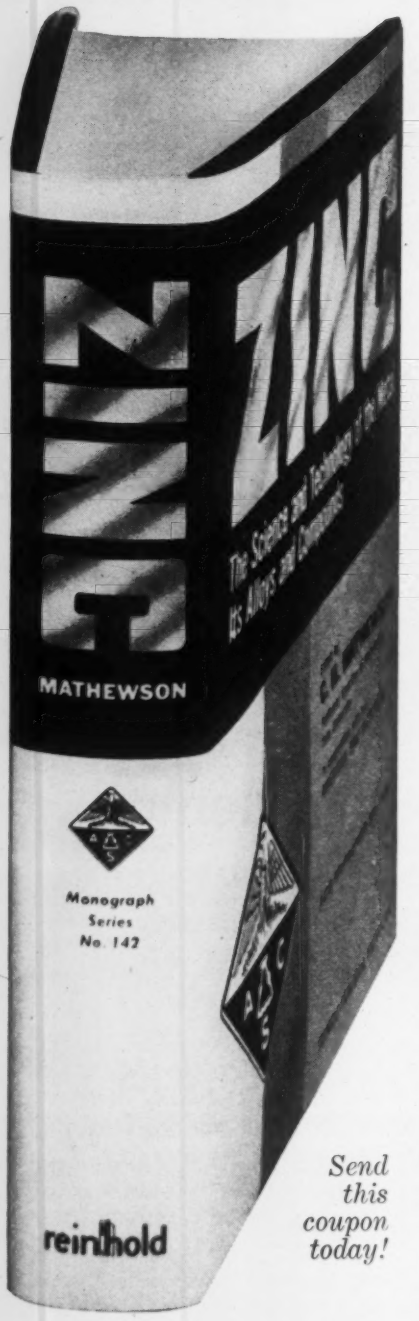

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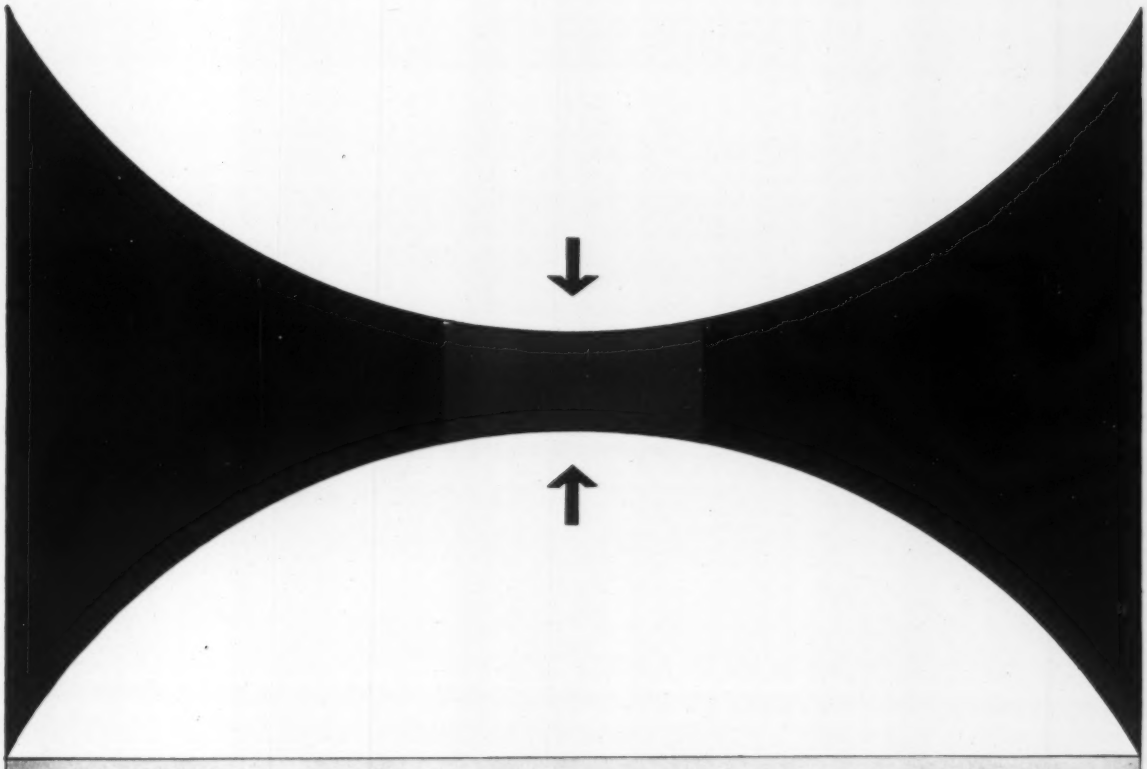

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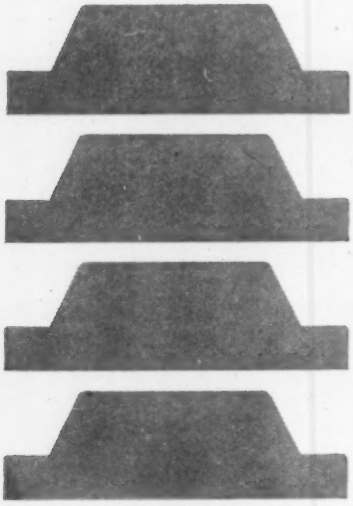

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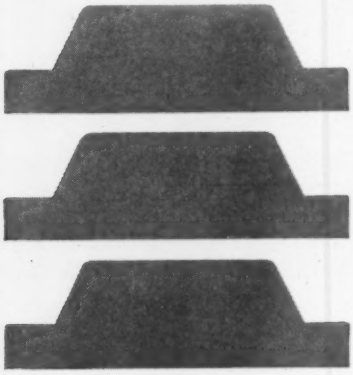

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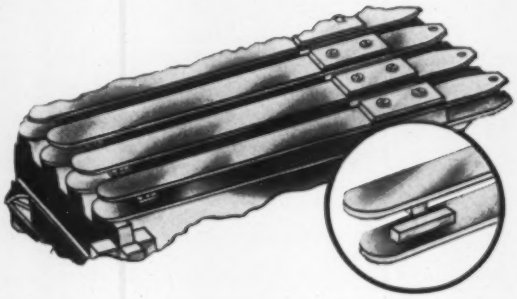

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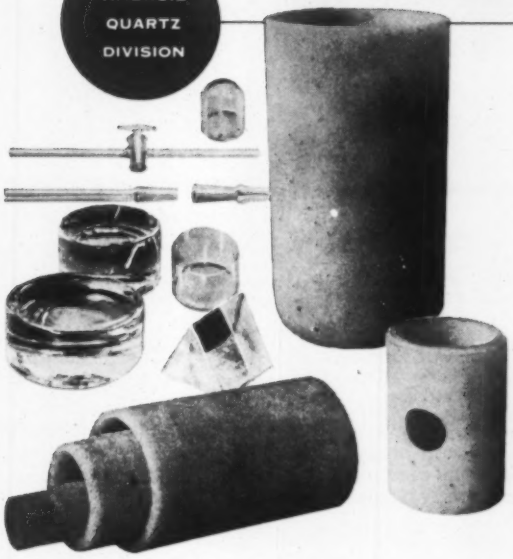

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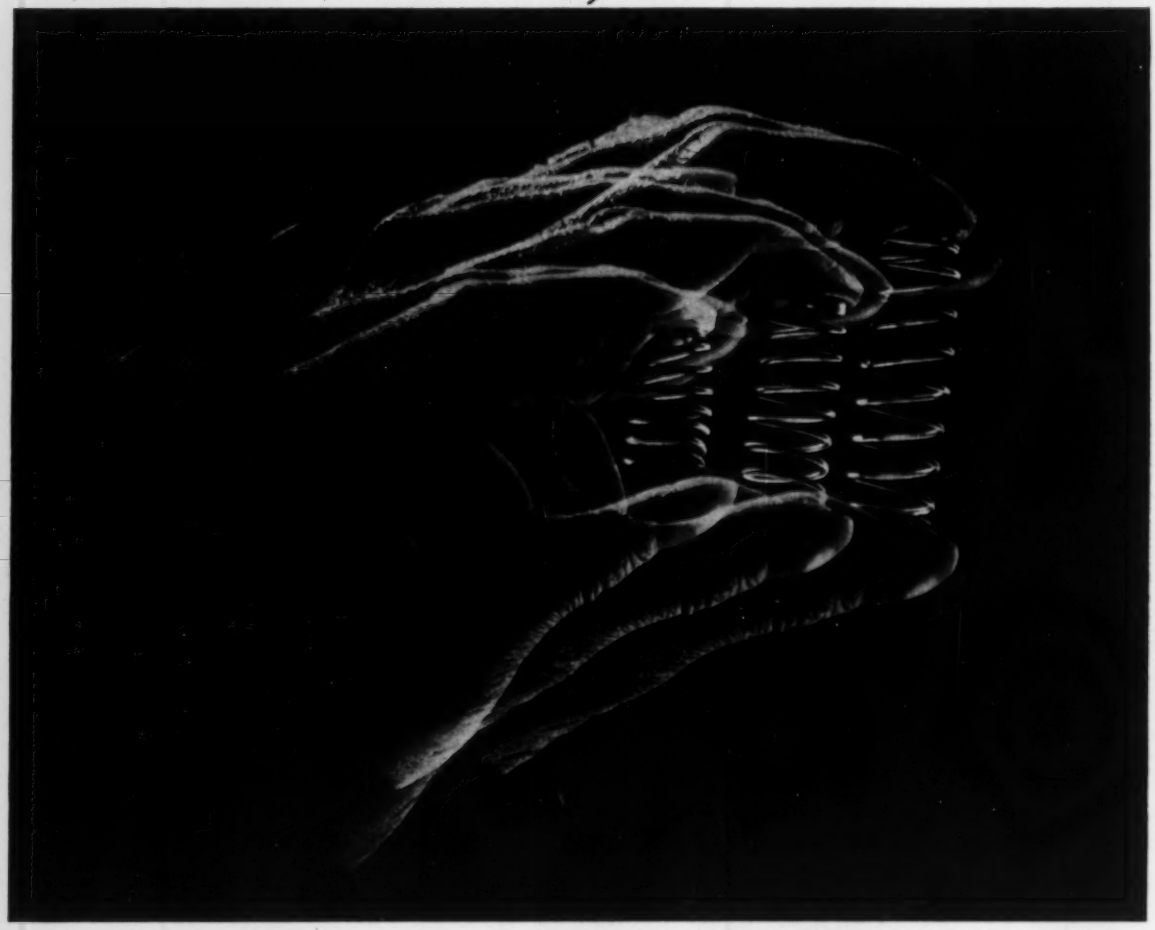

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5357	O, H-32, H-34, H-36, H-38	X	X	X	X	X	Decorative applications where anodized finishes are involved
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STAUFFER-TEMESCAL COMPANY
Richmond, California

Kindly send me:

- ☐ Data Sheet on Forgeable Tungsten
- ☐ Data Sheets on other Refractory Metals and Alloys
- ☐ Information on the Stauffer-Temescal electron beam furnace

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WHO EVER HEARD OF FORGEABLE TUNGSTEN?

Nobody... until Stauffer-Temescal Company made it in this ultra-pure form! Hardness and extreme high-temperature strength are typically tungsten. Impact resistance at all temperatures has been greatly increased. Yet because of the new ductility, forging and other fabrication are now successfully done on conventional steel-working equipment. *Forgeable* tungsten is a major breakthrough in refractory metals technology. This is an exclusive development of Stauffer-Temescal Company. Electron beam processing with critical composition control has greatly reduced grain size and created a random, highly uniform crystal structure. This virtually eliminates the lines of crystallographic weakness which induce fracture in ordinary tungsten. *Forgeable* tungsten and molybdenum are products of Stauffer research. Other exciting developments in electron beam processing are alloys of tungsten and tantalum, columbium and other refractory metals. Use the coupon on the opposite page for detailed information.

FORGEABLE TUNGSTEN AND MOLYBDENUM ARE PRODUCED BY STAUFFER-TEMESCAL COMPANY

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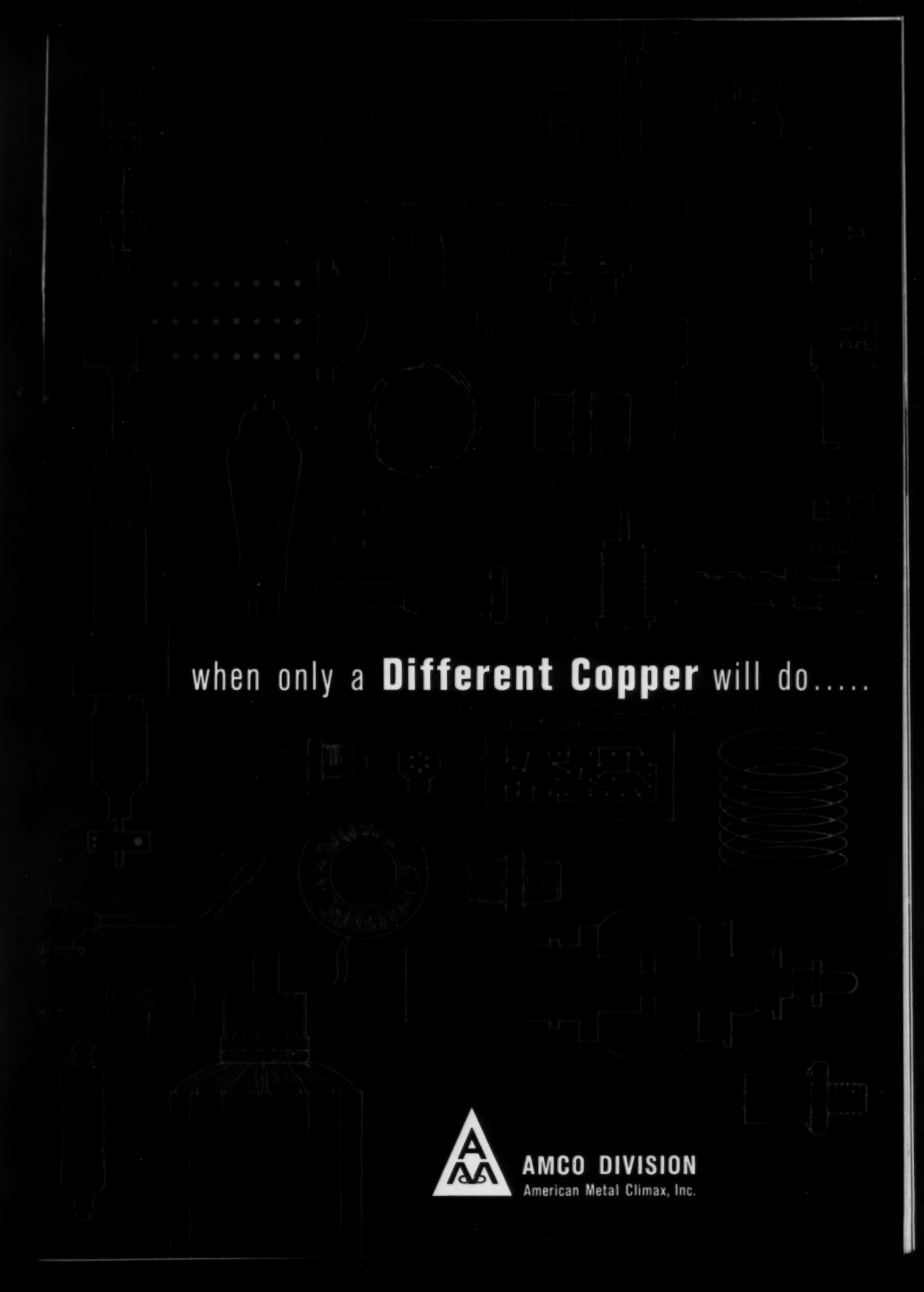
For more information, circle No. 539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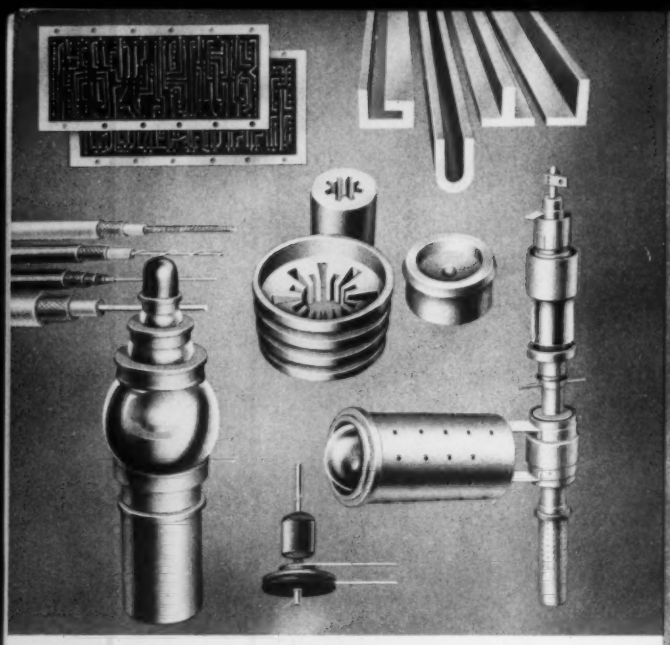

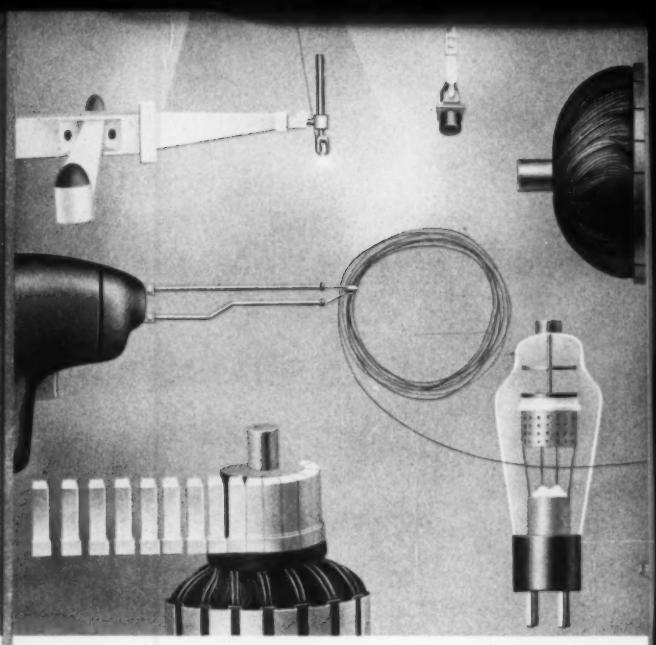

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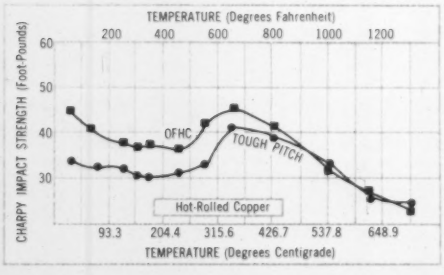
When you need conductivity of 101.5% IACS plus good formability at high strength levels

DISTINCTIVE CHARACTERISTICS: Totally free of oxides and residual deoxidizers, OFHC is 99.99% pure copper. For more than 20 years it has been recognized as the *one* copper able to meet all demands for precision electronic and electrical applications. OFHC offers high conductivity . . . excellent hot and cold workability . . . immunity to hydrogen embrittlement . . . soundness and high density to assure total vacuum . . . low volatility under high vacuum . . . adherent oxide scale . . . superior anodic action in electroplating.

APPLICATIONS: OFHC is the preferred copper for essential parts of electronic components such as high-frequency oscillators . . . magnetrons . . . triodes . . . tubes requiring glass-to-metal seals. Rotary components of power-generating equipment and other items requiring the highest obtainable electrical and thermal conductivity rely on OFHC.

IMPACT RESISTANCE OF OFHC AND TOUGH PITCH COPPER



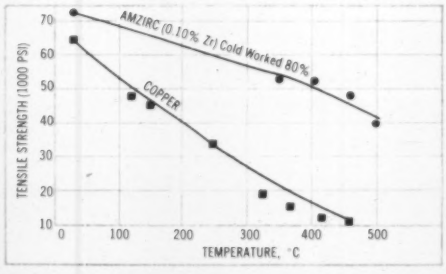
AMZIRC®

When you need tensile strength of up to 52,000 psi at 400°C plus conductivity of 95% IACS

DISTINCTIVE CHARACTERISTICS: AMZIRC consists of OFHC Copper and a rigidly controlled addition of high-purity Zirconium. The designer will find in AMZIRC high conductivity . . . retention of strength at elevated temperatures where copper and conventional high-conductivity alloys weaken . . . extreme notch toughness . . . transverse properties equal to longitudinal properties . . . hardness . . . exceptional hot and cold workability.

APPLICATIONS: Typical of the many products that have been improved or made possible by AMZIRC's unique combination of characteristics are high-temperature magnet wire . . . commutators and collector rings . . . rotor wedges . . . resistance welding wheels and tips . . . electron tube studs and side rods . . . rectifier bases.

TENSILE STRENGTH vs TEMPERATURE



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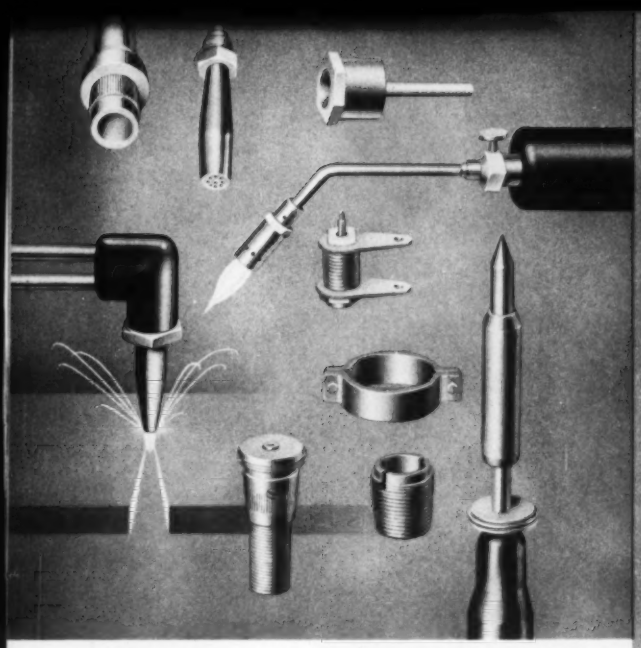
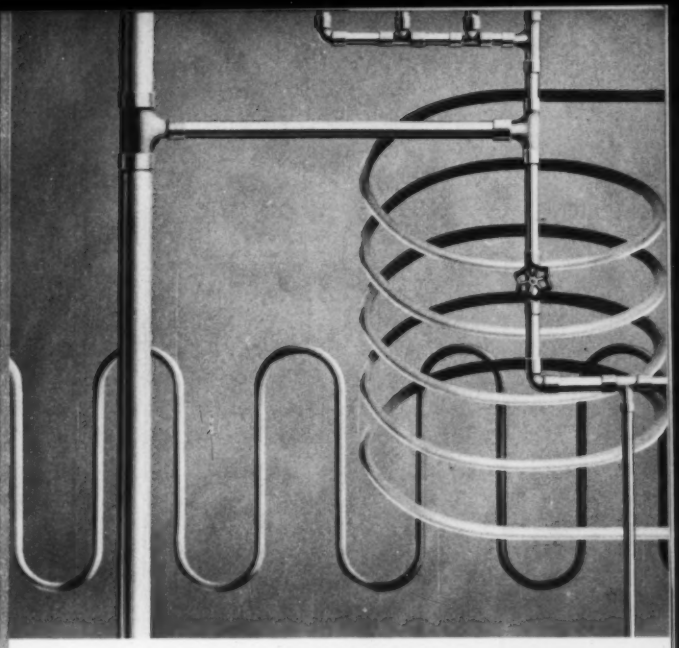




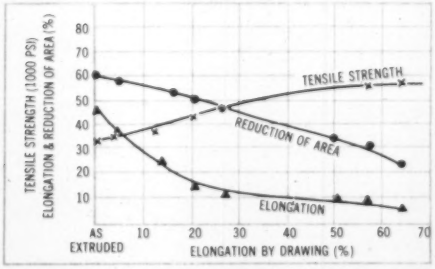
AMSULF®

When you need machinability rating of 90 and good workability, plus conductivity of 96% IACS

DISTINCTIVE CHARACTERISTICS: AMSULF is produced by combining OFHC Copper and a nominal 0.3% sulfur. This alloy provides high conductivity . . . rapid cutting rates . . . short chip formation . . . low power consumption relative to tool bite . . . excellent hot and cold workability . . . freedom from hydrogen embrittlement . . . fine surface finish and corrosion resistance.

APPLICATIONS: AMSULF is ideal for machined parts, especially automatic screw machine products. Its hot and cold workability and immunity to hydrogen embrittlement allow fabricating and finishing techniques impossible with conventional free-cutting coppers. Representative of the parts now being produced from AMSULF are flame-cutting nozzles . . . parts for motors and switches . . . electrical connectors, clamps, and clips . . . soldering iron tips . . . studs and terminals.

RELATIONSHIP OF ELONGATION, REDUCTION OF AREA, AND TENSILE STRENGTH



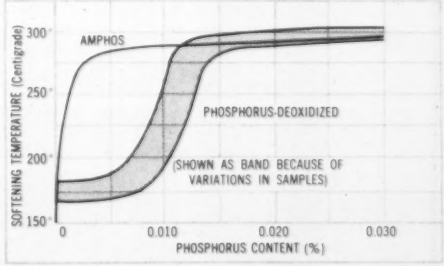
AMPHOS®

When you need exceptional hot and cold workability plus rapid piercing and drawing rates

DISTINCTIVE CHARACTERISTICS: Unlike ordinary phosphorus-*deoxidized* copper, AMPHOS is produced by adding to *oxygen-free* OFHC Copper a rigidly controlled amount of phosphorus. This results in a high-purity copper having uniform distribution of a predetermined phosphorus content. Distinguishing AMPHOS are high density . . . free-scaling properties . . . freedom from hydrogen embrittlement . . . improved cold workability . . . absence of voids . . . high softening temperature.

APPLICATIONS: AMPHOS should be specified for all tube, pipe, and related products where exacting specifications or fabricating techniques result in an appreciable number of rejects when ordinary phosphorized copper is used. Its suitability for welding and brazing and immunity to embrittlement make AMPHOS a superior material for condenser tubes . . . heat exchange units . . . coils . . . complex piping.

SOFTENING TEMPERATURE



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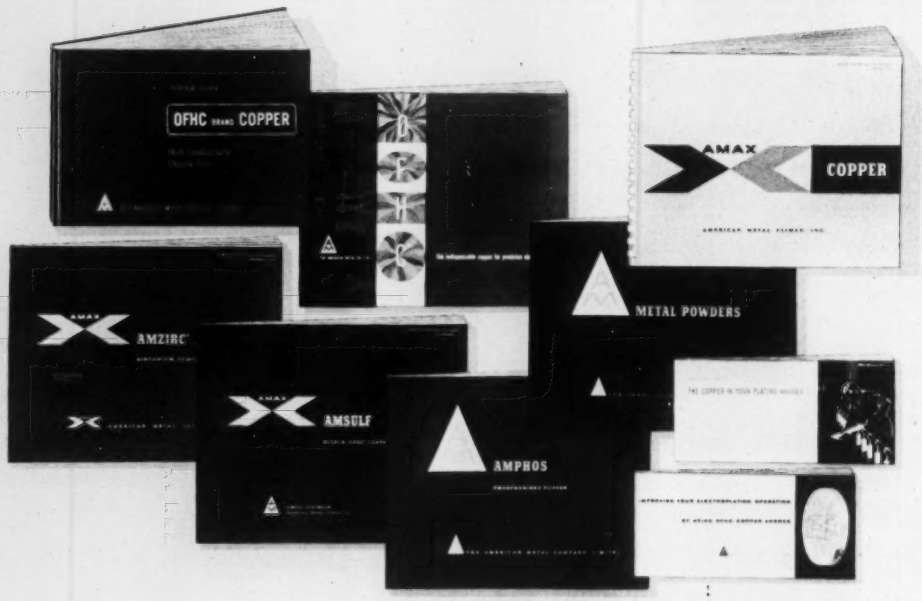

Free Technical Literature on AMCO's Unconventional Coppers

One of AMCO's coppers with unique combinations of characteristics may hold the elusive answer to your design problem. Another may help you hone your product's competitive edge. Starting point in discovering how to put these unusual metals to work for you are these books, booklets, and technical papers. There's no charge or obligation, of course. Also available without cost is metallurgical design service. Just contact the AMCO Technical Service Section.

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- **"TECHNICAL SURVEY OF OFHC COPPER"**
  122 pages, hardbound comprehensive reference text; Pub C-100
- **"OFHC...PREMIUM COPPER FOR PRECISION ELECTRONICS"**
  8 pages, Pub C-13
- **"AMZIRC...HIGH-CONDUCTIVITY ALLOY WITH HIGH STRENGTH AT ELEVATED TEMPERATURES"**
  8 pages, Pub C-16
- **"AMSULF...FREE-MACHINING ALLOY WITH HIGH CONDUCTIVITY AND UNIQUE WORKABILITY"**
  8 pages, Pub C-17

You will find investigation of the other products in the AMCO Copper Line rewarding, too. The publications covering them are also yours for the asking.

Electrolytic Copper Powders, Copper Alloy Powders, and Pre-Alloyed Filter Powders

- **"AMCO NON-FERROUS METAL POWDERS"**
  16 pages, Pub C-14

OFHC Anodes for Superior Electroplating

- **"THE COPPER IN YOUR PLATING ANODES"**
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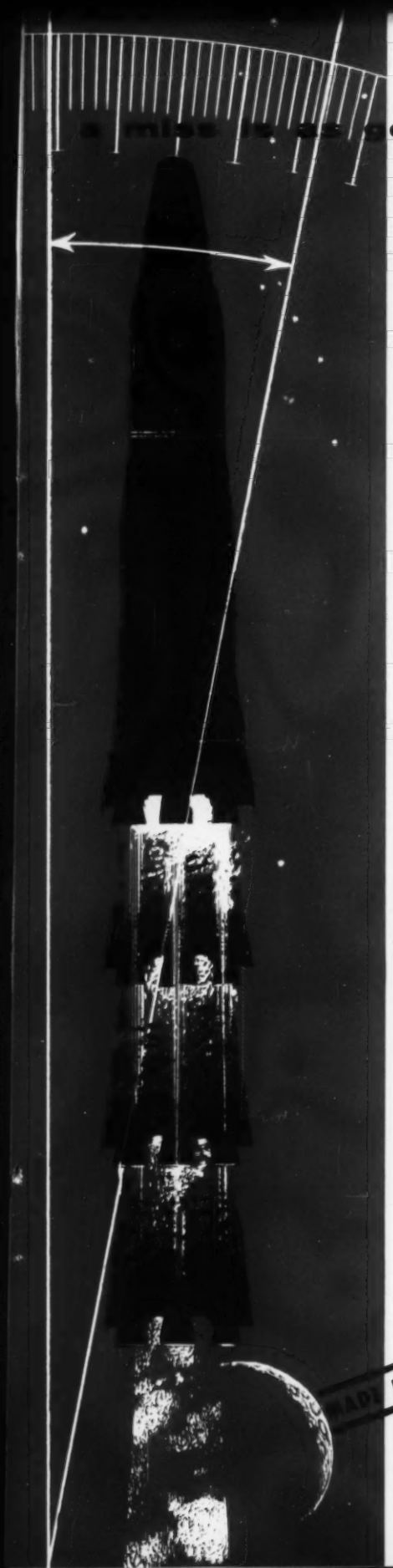

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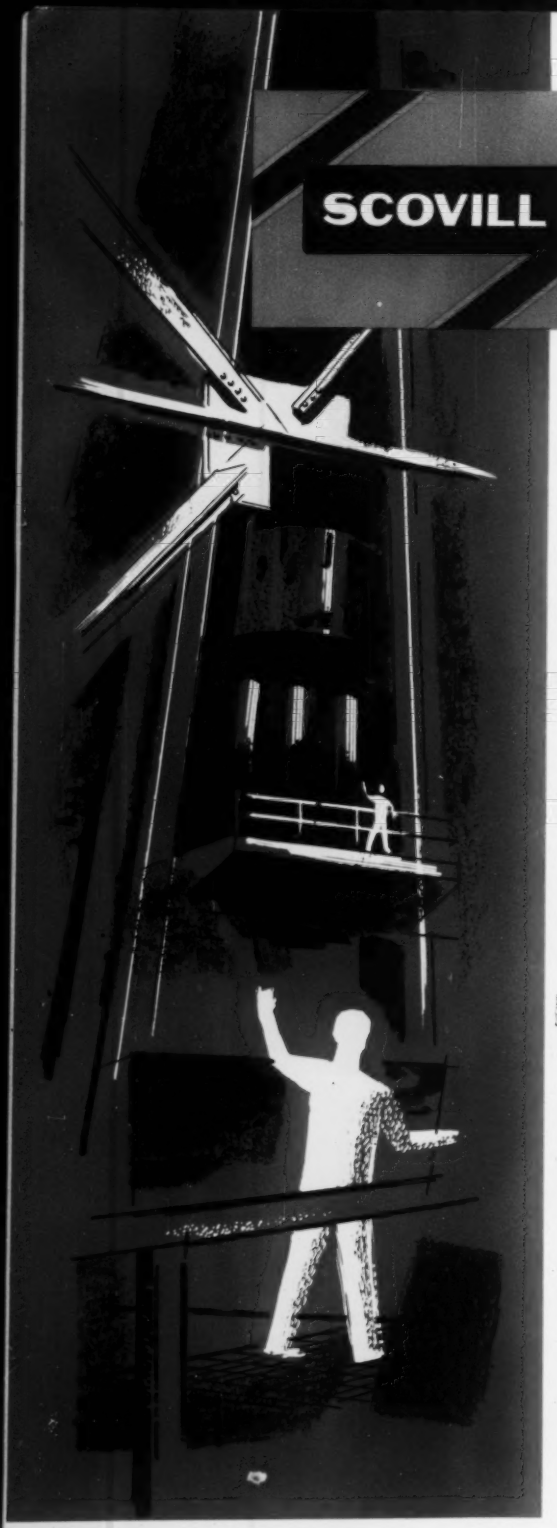

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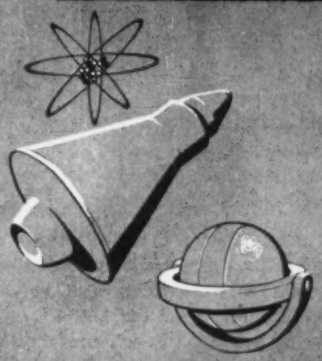
QMV® BERYLLIUM

The high temperature light metal with important thermal and nuclear properties.

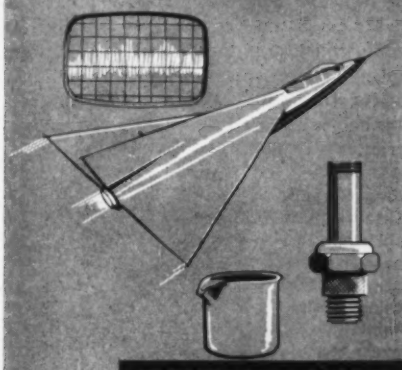


QMV beryllium, available in block, sheet, extrusions and forgings, can be machined, fabricated and joined by adaptations of standard techniques. Beryllium is being used extensively in nuclear devices as a moderator or reflector, in guidance devices, and in the design of advanced aircraft, for structural and heatsink applications.

	BLOCK	SHEET	EXTRUSIONS
ULTIMATE TENSILE (psi)	40,000	75,000	90,000
TENSILE YIELD (psi)	30,000	55,000	65,000
ELONGATION (%)	1-4	5-10	7-15
YOUNGS MODULUS	44,000,000 psi		
SPECIFIC HEAT	0.46 BTU/lb./°F		
THERMAL CONDUCTIVITY	0.3 BTU/ft.²/Sec (°F/in.)⁻¹		
ELECTRICAL CONDUCTIVITY	40-45% I.A.C.S		
DENSITY	1.85 g./cc.		
MELTING POINT	2345°F		
REFLECTIVITY—WHITE LIGHT	55%		
NEUTRON SCATTERING CROSS SECTION	7 BARNS/ATOM		
NEUTRON ABSORPTION CROSS SECTION	0.01 BARNS/ATOM		

UOX® BERYLLIUM OXIDE

The sinterable oxide for high performance applications.

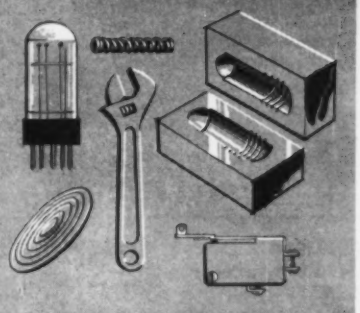


UOX, the high purity, sinterable ceramic oxide, is available as powder, crucibles, and special shapes fabricated to precision tolerances. Applications include nuclear moderators, reflectors and fuel matrices, heatsinks for aircraft and electronic devices, electronic tube components and metallurgical crucibles.

	ROOM TEMP.	2200°F.
COMPRESSIVE STRENGTH (psi)	114,000	20,000
TENSILE STRENGTH (psi)	18,000	4,000
MODULUS OF RUPTURE (psi)	35,000	14,000
MODULUS OF ELASTICITY (psi x 10^6)	45	20
SPECIFIC HEAT (BTU/lb./°F.)	0.24	0.57
THERMAL CONDUCTIVITY (BTU/hr./ft.²/°F./ft.)	125	9.7
RESISTIVITY OF LOW DENSITY BeO (Ohm-cm. x 10^6)	7000	4
SPECIFIC GRAVITY	3.008	
MELTING POINT (°F.)	4858	
COEFFICIENT OF EXPANSION (in/in/°F. x 10^{-6}) R.T.-500°F.	4.4	
COEFFICIENT OF EXPANSION (in/in/°F. x 10^{-6}) R.T.-2200°F.	6.2	
THERMAL SHOCK RESISTANCE	Excellent	
DIELECTRIC CONSTANT (10^7 cps)	5.9	
LOSS FACTOR (10^7 cps)	0.0004	

BERYLLIUM COPPER

High strength, good conductivity, corrosion and wear resistance, and excellent fatigue strength.



Available as casting alloy, master alloy, billets, forgings, bar, plate, and precision-rolled strip, these versatile alloys fill a wide range of uses including mechanical springs, electrical contacts, diaphragms, bellows, connectors, plastic mold cavities, non-sparking tools, switchgear, welding electrodes and wear surfaces.

TYPICAL MECHANICAL PROPERTIES OF BERYLLIUM COPPER PRECISION STRIP.

		BEFORE HEAT TREATMENT		AFTER HEAT TREATMENT		
Alloy	Temper	Tensile Strength psi	Elong. % in 2 in.	Tensile Strength psi	Elong. % in 2 in.	Elec. Cond. % IACS
25	Annealed	60- 78,000	35-60	165-190,000	4-10	22-25
	Hard	100-120,000	2- 8	190-215,000	1- 4	22-25
165	Annealed	60- 78,000	35-60	150-180,000	4-10	22-25
	Hard	100-120,000	2- 8	180-200,000	1- 4	22-25
10	Annealed	35- 55,000	20-35	100-110,000	8-12	48-55
	Hard	70- 85,000	5-10	110-125,000	5- 8	48-52
35	Annealed	35- 55,000	20-35	100-110,000	8-12	48-55
	Hard	70- 85,000	5-10	110-125,000	5- 8	48-52
25	XHM	Mill-hardened		170-185,000	3- 7	25-33
165	XHM	Mill-hardened		160-175,000	3- 7	25-33

OTHER BRUSH BERYLLIUM PRODUCTS

BERYLLIUM COMPOUNDS: Beryllium Fluoride, Hydroxide, Nitrate, Sulfate.
SYNTHETIC MICA: Powder and Block.
PRECISION-ROLLED STRIP: Phosphor-Bronze, Brass, Nickel-Silver, Stainless Steel.
ALLOYS: Beryllium-Aluminum, Beryllium-Nickel, Special Alloys.

Whether your problem is improving household appliances, or designing for interstellar exploration, beryllium or its oxide and versatile alloys should have a place in your planning. For more data, or application assistance, contact us at 5209 Euclid Avenue or ENdicott 1-5400 in Cleveland, Ohio.

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HOT ORGANIC COATINGS

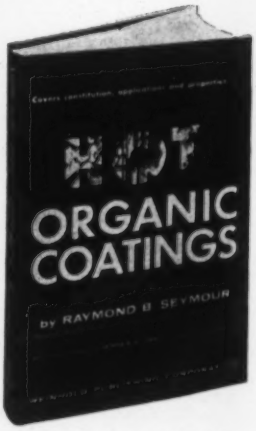
Just Published!

by RAYMOND B. SEYMOUR
President, Alcylite Plastics and Chemical Corporation
with a special chapter by **GEORGE B. McCOMB**
Consultant to Leading Suppliers of Pipe Line Coatings

1959, 225 pages, $7.50

The constitution, applications and properties of hot organic protective coatings are concisely presented here. The book contains chapters on widely used hot organic materials such as asphalt, coal tar pitch, petroleum waxes and cellulose derivatives. Specific information on formulations of proprietary products is included. Additional chapters deal with hot melt applications without solvent such as peel coatings, protective linings, flame spraying and the fluidized bed process. One chapter on hot applied coal tar pitch base coatings is supplied by George B. McComb, consultant to the leading suppliers of pipe line coatings. Hot spray techniques and the many advantages of this application are also covered. This book will be helpful to everyone using these coatings in any form.

CONTENTS: Coating Fundamentals; General Discussion of Hot Coatings; Asphalt and Related Products; Coal Tar Pitch; Petroleum Waxes; Synthetic Hydrocarbons Resins; Cellulose Derivatives; Animal, Vegetable & Insect Waxes; Miscellaneous Products; Applications in the Absence of Solvent; Hot Applied Coal Tar Pitch Base Coatings; Hot Solution Applications; Tests; Trends and Potentials of Hot Coatings; Glossary—Trade Names; Index.



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For high strength without excessive weight, the designer of this heavy truck chose Tenzaloy for the front engine supporting frame.

Why TENZALOY is the most widely used high-strength aluminum casting alloy

Among high-strength, self-aging aluminum casting alloys, Tenzaloy has won greatest acceptance and widest use by designers because of its unique all-round combination of properties. Outstanding among these special qualities are:

- High yield and tensile strength, combined with adequate ductility
- Exceptional machinability
- Remarkable dimensional stability
- High impact, shock resistance

When Tenzaloy is specified, one big problem is eliminated: heat treatment. Without any artificial thermal treatment, Tenzaloy castings will precipitation-harden at room temperature to give properties normally obtainable only by the expensive solution treating, quenching, and artificial aging of the heat-treatable alloys.

Here are typical properties for Federated Tenzaloy:

Tensile strength	35,000 psi
Yield strength	25,000 psi
Elongation (in 2 in.)	4-5%
Brinell hardness No.	74
Impact strength (Charpy in ft.-lbs.):	
Notched	3
Un-notched	14
Electrical conductivity	35%

Tenzaloy also is corrosion resistant, has superior ductility, and is easily anodized, dyed and polished to brilliant decorative finishes. Castability is excellent in green sand, plaster, investment, shell, oil-bonded sand and precision molds of all kinds. No special techniques are required for handling Tenzaloy in the foundry. Since Tenzaloy has mechanical properties equivalent to such common heat-treated alloys as 195T6, 355T6, 356T6 and 319T6, it can be substituted in applications where any of these heat-treated alloys are presently used.

It is particularly suited to high-strength designs where load carrying capacity and impact strength are essential. For example: frames, brackets, levers, bases, housings, missile ground handling equipment, jet aircraft turntables, explosion-proof enclosures, heavy-duty wheel hubs and cable drums, to name a representative few.

Tenzaloy can widen your design possibilities, increase production efficiency, improve your products, reduce costs. Get complete facts on its physical and mechanical properties by writing for Bulletin No. 103 R5 to: Federated Metals Division, American Smelting and Refining Company, 120 Broadway, New York 5, N. Y.

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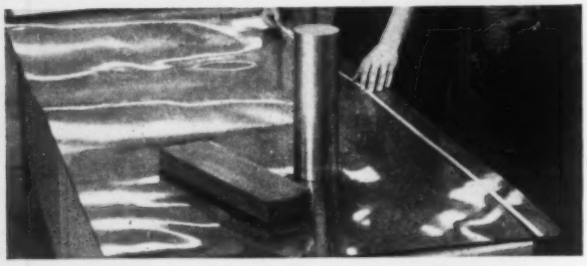

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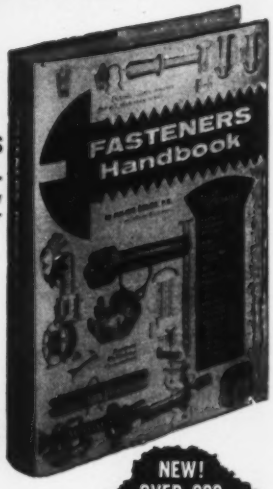

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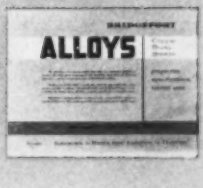

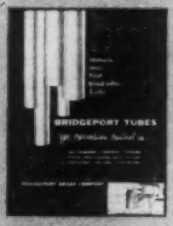

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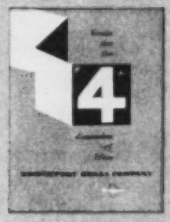

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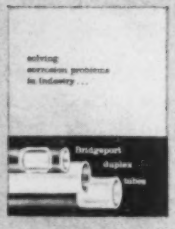

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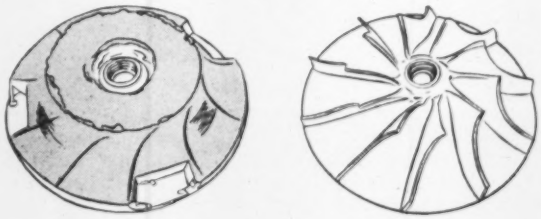

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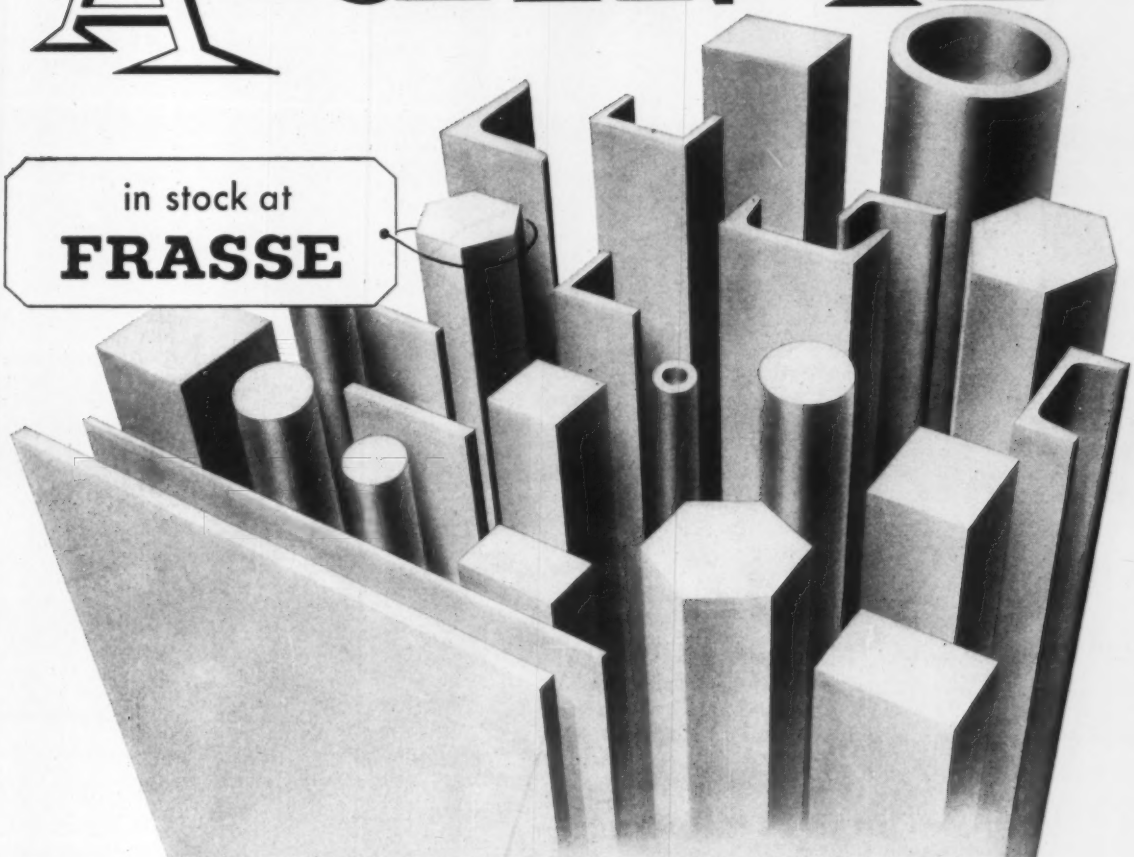

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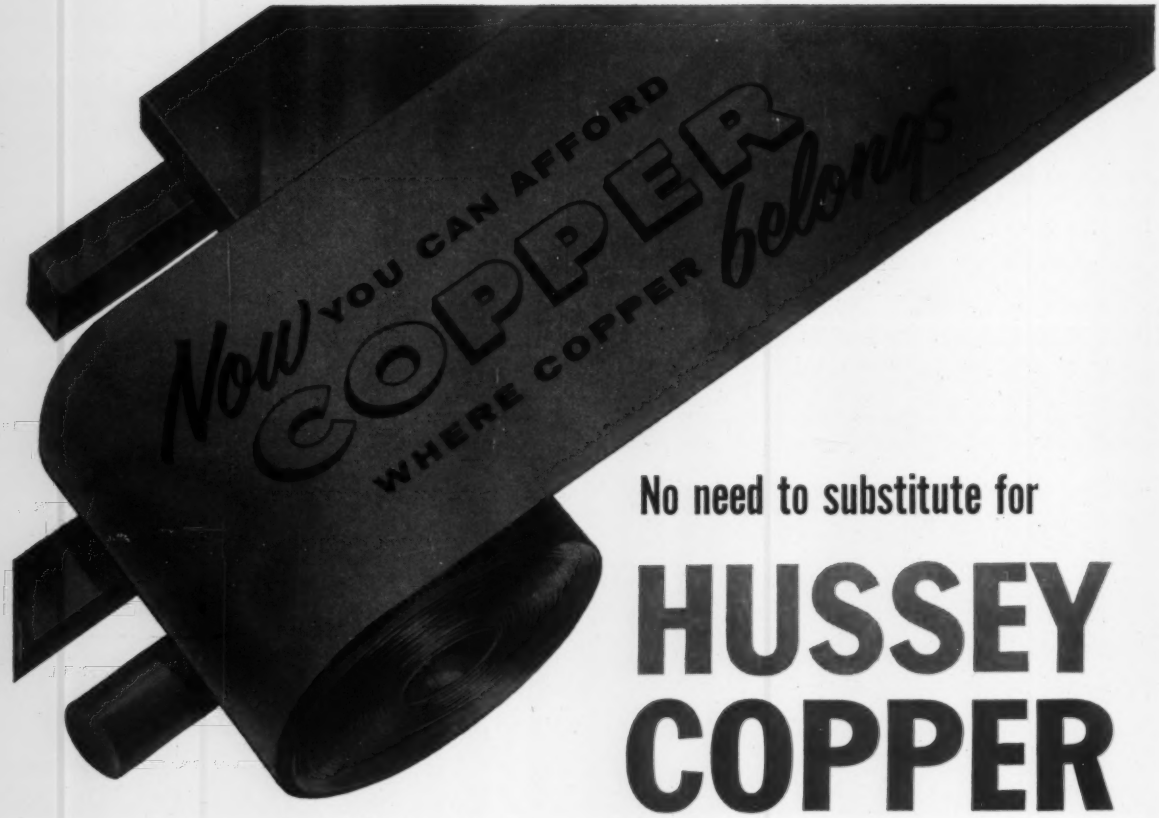

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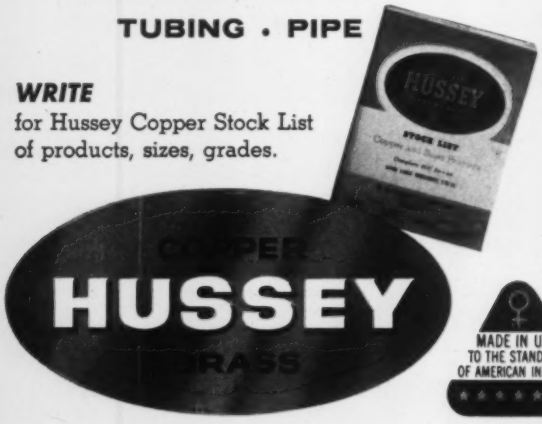

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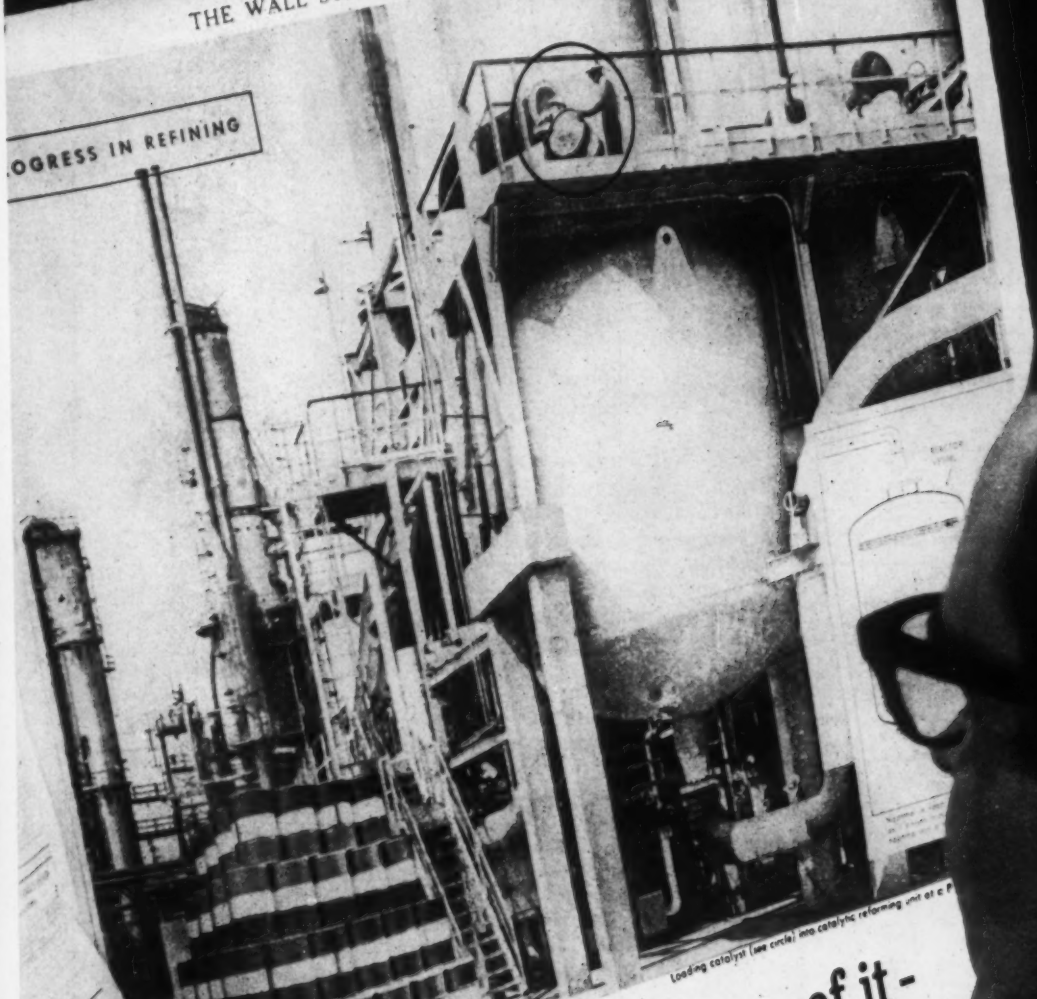

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Bibliography

Edited by

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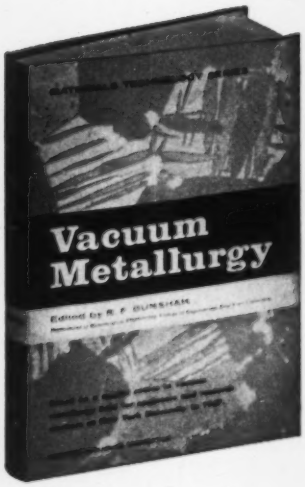

1958, 490 pages, $12.50

The aim of this book is to provide the engineering field with a complete, up-to-date reference on vacuum metallurgy. It is the result of a course on the subject held for engineers and research workers at New York University in 1957.

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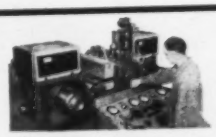

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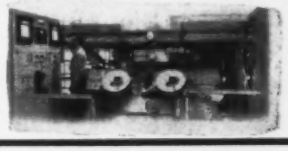

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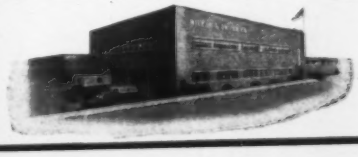
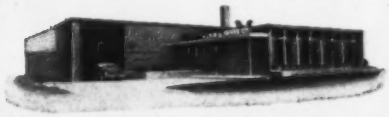


The Newark plant incorporates executive and general offices



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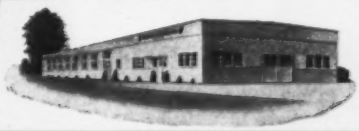

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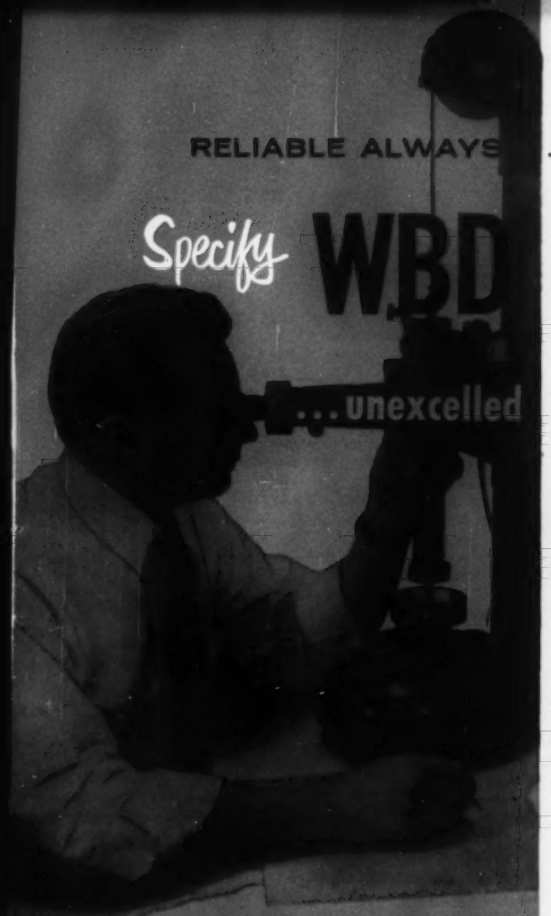

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Acrylics—Cast, Molded, Extruded

Type →		Cast Resin Sheets, Rods		Moldings	
		General Purpose Type I[a]	General Purpose Type II[a]	Grades 5, 6, 8[b]	High Impact Grade
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792	1.18-1.19	1.18-1.19	1.18-1.19	1.12-1.16
Ther Cond, Btu/hr/sq ft/°F/ft	[c]	0.10-0.15	0.10-0.15	0.12	0.12
Coef of Ther Exp, 10^{-5} per °F	D696	5	5	3-4	3
Spec Ht, Btu/lb/°F		0.35	0.35	0.35	0.34
Refractive Index	D542	1.485-1.500	1.485-1.495	1.489-1.493	—
Transmittance (luminous, 0.125 in.), %	D791	91-92	91-92	>92	—
Haze, %	D672	1-2	1-2	<3	—
Water Absorption (24 hr), %	D570	0.3-0.4	0.2-0.4	0.3-0.4	0.3
Flammability (0.125 in.), ipm	D635	0.5-2.5	0.5-2.5	0.9-1.2	—
MECHANICAL PROPERTIES					
Mod of Elast in Tension, 10^5 psi	D638	3.5-4.5	4.0-5.0	3.5-5.0	2.3-3.0
Ten Str, 1000 psi	D638	6-8	8-10	9.5-10.5	5.5-7.3
Elong (in 2 in.), %	D638	2-7	2-7	3-5	>25
Hardness (Rockwell)	D785	M90-100	M96-102	M80-103	L58-89
Impact Str (Izod notched), ft-lb/in.	D256	0.5	0.4	0.2-0.4	0.8-2.0
Mod of Elast in Flex, 10^5 psi	D790	3.5-4.5	4.0-5.0	3.5-5.0	2.8-3.6
Flex Str, 1000 psi	D790	12-14	15-17	15-16	8.7-11.5
Compr Yld Str (0.1% offset), 1000 psi	D695	10-12	12-14	14.5-17	—
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	$>10^{15}$	$>10^{15}$	$>10^{14}$	2.0×10^{16}
Dielec Str (short time), v/mil	D149	450-500	450-500	400	400-500
Dielec Const					
60 Cycles	D150	3.5-4.5	3.5-4.5	3.5-3.9	3.0-4.0
10^6 Cycles	D150	2.7-3.2	2.7-3.2	2.7-2.9	2.0-3.0
Dissip Factor					
60 Cycles	D150	0.05-0.06	0.05-0.06	0.04-0.06	0.03-0.04
10^6 Cycles	D150	0.02-0.03	0.02-0.03	0.02-0.03	0.01-0.02
Arc Resistance, sec		No track	No track	No track	No track
FABRICATING PROPERTIES					
Bulk Factor		—	—	1.8-2.2	—
Injection Molding					
Pressure, 1000 psi		—	—	10-20	10-20
Temperature, F		—	—	320-500	400-490
Hot Forming Temp, F		250-320	280-340	240-350	—
Extruding Temp, F		—	—	350-450	—
HEAT RESISTANCE					
Max Rec Svc Temp, F		140-160	180-200	155-190	—
Heat Dist Temp, F		150-170	190-210	166-202[d]	169-174
CHEMICAL RESISTANCE		Resist weak alkalis, acids and aliphatic hydrocarbons. Attacked by esters, ketones, aromatic hydrocarbons, chlorinated hydrocarbons and concentrated acids			
USES		Transparent aircraft enclosures, radio and television parts, lighting, drafting equipment, signs		Decorative and functional automotive parts, reflectors, protective goggle lenses, radio and television parts, household appliance parts	Shoe heels, control knobs, business machine and piano keys, pump parts, sprinkler heads, tool handles

[a] ASTM D702-46.
[b] Range includes typical values for Grades 5, 6, and 8, and may be superior to minimum or maximum requirements for these grades as detailed in ASTM D788-56T.
[c] Cenco-Fitch. [d] D788 specified values for Grades 5, 6 and 8: 149 F, 162 F, 183 F respectively.

Alkyds—Molded

Type →	ASTM	Granular (general purpose)	Putty (electrical)	Glass-Reinforced (impact)
PHYSICAL PROPERTIES				
Specific Gravity	D792	2.22–2.24	2.05–2.15	2.00–2.08
Ther Cond, Btu/hr/sq ft/°F/ft		0.35–0.60	0.35–0.60	0.20–0.30
Coef of Ther Exp, per °F	D696	1–3 x 10^{-5}	1–3 x 10^{-5}	1–3 x 10^{-5}
Water Absorption (24 hr), %	D570	0.08–0.10	0.05–0.08	0.07–0.10
Flammability, ipm	D635	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES				
Tensile Strength, 1000 psi	D651	3–4	3–4	6–10
Impact Strength (Izod notched), ft-lb/in.	D256	0.30–0.35	0.30–0.35	8–12
Mod of Elast in Flexure, psi	D790	22–27 x 10^5	22–27 x 10^5	22–28 x 10^5
Flexural Strength, 1000 psi	D790	7–10	7–10	14–17
Compressive Strength, 1000 psi	D690	16–20	18–20	24–28
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm-cm	D257	10^{14}	10^{14}	10^{14}
Dielectric Strength (step by step), v/mil	D149	300–350	300–350	300–350
Dielectric Constant				
60 Cycles	D150	6.0–6.5	6.0–6.5	5.2–6.0
10^6 Cycles	D150	4.8–5.0	4.2–4.5	4.0–4.5
Dissipation Factor				
60 Cycles	D150	0.050–0.060	0.035–0.040	0.02–0.03
10^6 Cycles	D150	0.016–0.018	0.014–0.015	0.017–0.022
FABRICATING PROPERTIES				
Bulk Factor	D954	1.95–2.15	1.1–1.2	9–11
Compression Molding				
Pressure, 1000 psi		1.0–1.5	0.8–1.0	1.5–2.0
Temperature, F		270–330	270–330	270–330
HEAT RESISTANCE				
Max Rec Svc Temp (limited periods), F		350	300	350
Heat Dist Temp (264 psi), F	D648	350–400	350–400	>400
CHEMICAL RESISTANCE		Resistant to weak acids; attacked by alkalis; practically unattacked by organic liquids such as alcohols, hydrocarbons and fatty acids		
USES		Ignition parts, fuse blocks, switch and circuit breaker covers and bases, molded resistors and capacitors, television tuner segments		

Cellulose Acetate—Molded, Extruded

Type →		Type I —Medium[a]	Type II—Hard[a]			Type III —Soft[a]
			H6	H4	H2	
PHYSICAL PROPERTIES	ASTM					
Specific Gravity	D792...	1.23–1.34	1.29–1.34	1.28–1.34	1.27–1.34	1.27–1.34
Ther Cond, Btu/hr/sq ft/°F/ft	C177...	0.10–0.19	0.10–0.19	0.10–0.19	0.10–0.19	0.10–0.19
Coef of Ther Exp, 10^{-5} per °F	D696...	4.4–9.0	4.4–9.0	4.4–9.0	4.4–9.0	4.4–9.0
Refractive Index	D542...	1.46–1.50	1.46–1.50	1.46–1.50	1.46–1.50	1.46–1.50
Spec Ht, Btu/lb/°F	.....	0.3–0.42	0.3–0.42	0.3–0.42	0.3–0.42	0.3–0.42
Transmittance (luminous), %	D791...	80–90	75–90	75–90	80–90	80–95
Haze, %	D672...	2–10	2–15	2–15	2–10	2–8
Water Absorption (24 hr), %	D570...	1.7–5.7	1.5–3.5	1.7–3.6	1.7–5.3	2.3–6.5
Flammability, ipm[b]	D635...	0.5–2.0	0.5–2.0	0.5–2.0	0.5–2.0	—
MECHANICAL PROPERTIES						
Ten Str, 1000 psi	D638...	2.7–6.5	6–8.5	5.4–8.2	4.6–7.5	1.9–4.7
Elong (in 2 in.), %	D638...	18–54	6–31	10–35	17–40	32–70
Hardness (Rockwell)	D785...	R68–115	R112–123	R106–121	R95–119	R39–103
Impact Str (Izod notched), ft-lb/in.	D256...	1.1–4.0	0.4–1.9	0.6–2.3	0.7–2.7	1.7–5.2
Mod of Elast in Flex, 10^5 psi	.....	1.1–3.5	2.6–4.0	1.9–3.4	1.6–3.3	0.5–2.5
Compr Str, 1000 psi	D695...	14.5–25	25–36	22–33	19–28	13–20
ELECTRICAL PROPERTIES						
Vol Res, ohm-cm	D257...	10^{10}–10^{13}	10^{10}–10^{13}	10^{10}–10^{13}	10^{10}–10^{13}	10^{10}–10^{13}
Dielec Str (short time), v/mil	D149...	250–600	250–600	250–600	250–600	250–600
Dielec Const						
60 Cycles	D150...	3.5–7.5	3.5–7.5	3.5–7.5	3.5–7.5	3.5–7.5
10^6 Cycles	D150...	3.2–7.0	3.2–7.0	3.2–7.0	3.2–7.0	3.2–7.0
Dissipation Factor						
60 Cycles	D150...	0.03–0.38	0.03–0.38	0.03–0.38	0.03–0.08	0.03–0.08
10^6 Cycles	D150...	0.03–0.33	0.03–0.33	0.03–0.33	0.03–0.33	0.03–0.33
FABRICATING PROPERTIES						
Bulk Factor		2.0–2.6	2.0–2.6	2.0–2.6	2.0–2.6	2.0–2.6
Compression Molding						
Pressure, psi		500–5000	500–5000	500–5000	500–5000	500–5000
Temperature, F		300–400	390–475	375–450	350–425	290–330
Injection Molding						
Pressure, 1000 psi		8–32	8–32	8–32	8–32	8–32
Temperature, F		355–450	420–490	410–480	390–460	335–395
Extruding Temp, F		335–450	420–450	405–455	390–420	335–365
HEAT RESISTANCE		As these are thermoplastic materials, they gradually become softer as the temperature rises. Maximum service temperature depends on such factors as formula, design of part, humidity and service conditions				
CHEMICAL RESISTANCE		Unattacked by water, salt water solutions, white gasoline, oleic acid, 5% acetic acid and dilute sulfuric acid. Decomposed by 30% sulfuric, 10% nitric and 10% hydrochloric acids; sodium hydroxide; and 10% ammonium hydroxide. Dissolved by acetone and ethyl acetate				
USES		Automotive and radio knobs, tool handles, business machine keys. Electrical items such as fluorescent lamp supports, coil spools and contact bases. Toys and novelties, sunglass goggles and frames, spectacle frames, buttons and tags, appliance housings, shoe heels				

[a] ASTM D706-55T.
[b] Self-extinguishing compositions are available.

Cellulose Acetate Butyrate and Cellulose Propionate—Molded, Extruded

Type →		Cellulose Acetate Butyrate			Cellulose Propionate[b]
		Type I[a] (Medium)	Type II[a] (Hard)	Type III[a] (Soft)	
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792	1.16-1.24	1.19-1.25	1.15-1.22	1.18-1.24
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.10-0.19	0.10-0.19	0.10-0.19	0.10-0.19
Coef of Ther Exp (max), per °F	D696	6-9 x 10^{-5}	6-9 x 10^{-5}	6-9 x 10^{-5}	7-9 x 10^{-5}
Refractive Index	D542	1.46-1.49	1.46-1.49	1.46-1.49	1.46-1.48
Spec Ht, Btu/lb/°F		0.3-0.4	0.3-0.4	0.3-0.4	0.3-0.4
Transmittance (luminous), %	D791	80-92	75-92	85-95	80-92
Haze, %	D672	2-5	2-5	2-5	2-5
Water Absorption (24 hr), %	D570	1.3-2.1	1.5-2.2	1.1-2.1	1.2-2.0
Flammability, ipm[c]	D635	0.5-1.5	0.5-1.5	0.5-1.5	1.0-1.5
MECHANICAL PROPERTIES					
Ten Str, 1000 psi	D638	2.9-5.7	5.0-6.8	1.9-3.8	1.5-7.5
Elong, %		47-66	38-54	60-74	50-60
Hardness (Rockwell)		R79-112	R108-114	R59-95	R20-120
Impact Str (Izod notched), ft-lb/in.	D256	1.0-4.3	0.6-2.4	2.5-5.4	0.8-11.0
Mod of Elast in Flex, psi		0.93-1.7 x 10^5	1.5-2.0 x 10^5	0.74-1.3 x 10^5	1.6-3.3 x 10^5
Flex Str, 1000 psi		No break	No break	No break	No break
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	10^{10}-10^{12}	10^{10}-10^{12}	10^{10}-10^{12}	10^{12}-10^{15}
Dielec Str (short time), v/mil	D149	250-400	250-400	250-400	300-450
Dielec Const					
60 Cycles	D150	3.5-6.4	3.5-6.4	3.5-6.4	—
10^6 Cycles	D150	3.2-6.2	3.2-6.2	3.2-6.2	3.4-3.6
Dissip Factor					
60 Cycles	D150	0.01-0.04	0.01-0.04	0.01-0.04	—
10^6 Cycles	D150	0.01-0.04	0.01-0.04	0.01-0.04	0.02-0.03
FABRICATING PROPERTIES					
Bulk Factor		2.0-2.4	2.0-2.4	2.0-2.4	1.6-2.0
Compression Molding					
Pressure, 1000 psi		18	18	0.5-5	—
Temperature, F		285-340	320-390	265-305	—
Injection Molding					
Pressure, 1000 psi		8-32	8-32	8-32	8-32
Temperature, F		355-440	390-480	335-395	335-480
Mold Shrinkage, in./in.		0.001-0.008	0.001-0.009	0.001-0.006	0.002-0.006
HEAT RESISTANCE					
Heat Dist Temp, F					
66 Psi	D648	156-197	188-233	139-164	130-200
264 Psi	D648	130-172	158-210	121-137	100-190
CHEMICAL RESISTANCE		Unaffected by 3% sulfuric, 5% acetic, 10% hydrochloric and oleic acids; discolored by 10% nitric acid. Unaffected by 1% sodium hydroxide and 2% sodium carbonate; slightly softened by 10% sodium hydroxide and discolored by 10% ammonium hydroxide. Unaffected by white gasoline, but swollen or dissolved by ethyl alcohol, acetone, ethyl acetate, ethylene dichloride, carbon tetrachloride and toluene. Unaffected by water, salt water and 3% hydrogen peroxide			
USES		Telephone handsets, steering wheels, automobile white-wall disks, film spools, irrigation tubing, radio housings. Electrical items such as fluorescent light supports, coil spools and contact bases.			Pen and pencil parts, telephone handsets. Other uses similar to those of butyrate

[a] ASTM D707-55T.
[b] Values given are for compounds having different plasticizer contents.
[c] Self-extinguishing cellulose acetate butyrate compounds are available.

Cellulose Nitrate and Ethyl Cellulose—Molded, Extruded

Type →		Cellulose Nitrate Sheet	Ethyl Cellulose Moldings		
			General Purpose	High Impact	
				A	B
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792	1.35-1.40	1.10-1.16	1.10-1.16	1.10-1.16
Ther Cond, Btu/hr/sq ft/°F/ft	Cenco-Fitch	0.133	0.092-0.167	0.092-0.167	0.092-0.167
Coef of Ther Exp, 10^{-5} per °F	D696	4.4-6.6	5.5-11	5.5-11	5.5-11
Refractive Index	D542	1.49-1.51	1.47	1.47	1.47
Transmittance (luminous), %	D791	89-92[a]	—	—	—
Haze, %	D672	2.0-4.0[a]	—	—	—
Water Absorption (24 hr), %	D570	1.0-2.0	1.2-2.0	0.8-2.0	1.0-2.0
Flammability (>0.050 in.), ipm	D635	[b]	0.5-1.5	0.5-1.5	0.5-1.5
MECHANICAL PROPERTIES					
Mod of Elast in Tension, 10^5 psi	D638	1.9-2.2	0.5-3.5	1.0-3.0	1.0-3.0
Ten Str, 1000 psi	D638	7-8	3-7	4-6.5	3-5
Strain at Fracture, %	D638	40-50	—	—	—
Hardness (Rockwell)	D785	R95-115	R80-120	R80-90	R70-80
Impact Str (Izod notched), ft-lb/in.	D758	5-7	1.7-6.0	3.5-6.0	4.0-7.0
Mod of Elast in Flex, 10^5 psi	D790	2.3-2.5	—	—	—
Flex Str, 1000 psi	D790	9-11[c]	4-10	6	4
Compr Str, 1000 psi	D695	22-35	—	—	—
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	10-15 x 10^{10}	10^{12}-10^{14}	10^{12}-10^{14}	10^{12}-10^{14}
Dielec Str (short time), v/mil	D149	300-600	350-500	350-500	350-500
Dielec Const					
60 Cycles	D150	7.0-7.5	—	—	—
10^6 Cycles	D150	6.4	2.8-3.5	2.8-3.3	3.0-3.6
Dissip Factor					
60 Cycles	D150	0.09-0.12	—	—	—
10^6 Cycles	D150	0.06-0.09	0.010-0.060	0.010-0.030	0.018-0.035
FABRICATING PROPERTIES					
Bulk Factor		—	1.8-2.4	1.8-2.4	1.8-2.4
Compression Molding					
Pressure, 1000 psi		—	0.5-5	0.5-5	0.5-5
Temperature, F		—	250-390	250-390	250-390
Injection Molding					
Pressure, 1000 psi		—	6-32	8-32	8-32
Temperature, F		—	350-500	350-500	350-500
Hot Forming Temperature, F		135-250	—	—	—
Extruding Temperature, F		180-200	300-450	350-450	350-450
HEAT RESISTANCE					
Max Rec Svc Temp, F		120-140	—	—	—
Heat Dist Temp, F					
66 Psi		200-220	—	—	—
264 Psi		140-160	120-160	130-145	125-140
CHEMICAL RESISTANCE		Resistant to 30% sulfuric acid, carbon tetrachloride, 10% sodium chloride, 10% nitric acid, 10% hydrochloric acid, 5% acetic acid, 2% sodium tetrachloride, distilled water, aliphatic and aromatic hydrocarbons, and < 1% sodium hydroxide. Soluble in ketones, esters, lower alcohols and glycol ethers. Attacked by concentrated sodium hydroxide, ethylene dichloride and 50% ethanol		Unaffected by 3 sulfuric, 5 acetic and 10% hydrochloric acids; 10% sodium hydroxide, 2% sodium carbonate and water. Slightly affected by 30 sulfuric and 10% nitric acids; and 10% ammonium hydroxide. Attacked by 95% ethyl alcohol, acetone, toluene and gasoline	
USES		Fountain pens, spectacle frames, drawing instruments, ping-pong and billiard balls		Radio housings, toothbrushes, pen and pencil barrels, tool handles	

[a] 1/8-in. sheet containing no color.
[b] Cellulose nitrate under 0.050 in. thick burns very rapidly (D568).
[c] No break; specimen failed by slipping through supports.

Diallyl Phthalate—Molded

Type →	ASTM	Orlon-Filled	Dacron-Filled	Asbestos-Filled	Glass Fiber-Filled
PHYSICAL PROPERTIES					
Specific Gravity	D792	1.31–1.34	1.40	1.65–1.70	1.55–1.59
Coef of Ther Exp, per °F	D696	1.5×10^{-5}	2.0×10^{-5}	3.5×10^{-5}	$2.2\text{–}2.6 \times 10^{-5}$
Water Abs (122 F, 48 hr), %		0.2–0.5	0.2–0.5	0.4–0.5	0.2–0.4
Flammability (ignition time), sec		68	84–90	70	70–400
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi[a]	D638	6×10^5	—	12×10^5	—
Ten Str, psi	D638	4500–6000	4600–6000	4000–5500	5500–7000
Hardness (Rockwell)	D785	M108	—	M107	M108
Impact Str (Izod notched), ft-lb/in.	D256	0.5–1.2	1.7–4.5	0.30–0.45	0.5–6.0
Flex Str, 1000 psi	D790	10–10.5	9–11.5	8–10	10–18
Compr Str, 1000 psi	D695	20–30	20–30	18–25	25
ELECTRICAL PROPERTIES					
Dielec Str, v/mil					
Short Time (dry)	D149	400	376–390	450	350–430
Short Time (wet[b])	D149	375	360–391	400	300–420
Step by Step (dry)	D149	350	350–374	400	300–420
Step by Step (wet[b])	D149	325	350–361	350	275–420
Dielec Breakdown, kv					
Short Time (dry)		65–75	70–80	55–80	63–70
Short Time (wet[b])		60–65	66–70	55	45–65
Step by Step (dry)		55–60	60–65	38–70	60–65
Step by Step (wet[b])		46–60	50–60	39–60	49–65
Dissip Factor[c]					
Dry	D150	0.023, 0.015	0.008, 0.015	0.05, 0.03	0.01, 0.015
Wet[d]	D150	0.026, 0.020	0.009, 0.017	0.042, 0.154	0.012, 0.020
Dielec Const[c]					
Dry	D150	3.9, 3.3	3.8, 3.4	5.2, 4.5	4.5, 4.2
Wet[d]	D150	4.1, 3.4	3.9, 3.6	4.8, 4.2	4.6, 4.4
Vol Res, megohm-cm[d]	D257	60,000	100–25,000	6000	40,000
Surface Res, megohms[d]	D257	25,000	500–25,000	6000	25,000
Arc Resistance, sec	D495	85–115	105–125	125–140	125
FABRICATING PROPERTIES					
Bulk Factor	D392	3.5–5.2	3.5–5.2	1.9–2.4	1.9–5.0
Compression Molding					
Pressure, psi		500–2000	500–2000	500–2000	500–2000
Temperature, F		270–290	270–290	270–320	270–320
Transfer Molding					
Pressure, psi		1000–5000	1000–5000	1000–5000	1000–5000
Temperature, F		270–290	270–290	270–310	270–310
Mold Shrinkage, in./in.		0.009	0.010	0.004–0.007	0.001–0.004
Post-Mold Shrinkage (480 hr, 257 F), in./in.		0.001	0.0006	0.0005	0.0005–0.0007
HEAT RESISTANCE					
Max Rec Svc Temp, F		300	300–370	350–450	400–450
Heat Dist Temp, F	D648	240–266	270–290	300–350	400–500
CHEMICAL RESISTANCE		Unaffected by weak acids and alkalis and organic solvents. Slightly affected by strong acids and alkalis			

[a] Conditioned 48 hr at 122 F.
[b] Tested after 48-hr immersion in water at 122 F.
[c] Values given for frequencies of 1 kc and 1 mc, in that order.
[d] Conditioned 30 days at 100% RH and 158 F.

Epoxies—Cast, Molded

Type →		Cast			Molded [b]
		General Purpose	Resilient	Heat Resistant	
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792...	1.12–2.4	1.0–1.25	1.15–3.2	1.8–1.85
Ther Cond, Btu/hr/sq ft/°F/ft	D325...	0.1–0.8	0.1	0.1–0.8	—
Coef of Ther Exp, per °F	D696...	$1.7–5.0 \times 10^{-5}$	$2.8–4.4 \times 10^{-5}$	$2.8–3.3 \times 10^{-5}$	1.4×10^{-5} [c]
Water Absorption (24 hr), %	D570...	0.1–0.5	0.4	0.01–0.2	0.06
Linear Mold Shrinkage, in./in.	.....	0.001–0.01	—	0.01	0.004–0.006
Flammability, ipm	D635...	0.3 to self-exting	—	0.3 to self-exting	Self-exting
MECHANICAL PROPERTIES					
Ten Str, 1000 psi	D651...	2–12	0.1–4.0	5–14	8–10
Elongation, %	D651...	2–6	150–10	2–5	—
Hardness (Rockwell)	D785...	M75–110	[a]	M90–110	M110
Impact Str (Izod), ft lb/in. notch	D256...	0.2–0.7	0.5–7.0	0.2–1.5	0.3–0.8
Mod of Elast in Flex, 10^5 psi	D790...	0.4–1.5	Up to 0.2	0.4–1.5	1.3–2.2
Flex Str, 1000 psi	D790...	8–20	Up to 15	8–20	11–15.7 [d]
Compr Str, 1000 psi	D695...	20–40	3–20	25–40	25–26
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257...	$10^{13}–10^{14}$	$10^{11}–10^{13}$	$10^{13}–10^{14}$	$0.1–9 \times 10^{15}$
Dielec Str (⅛ in.), v/mil					
Short Time	D149...	350–550	350–550	350–550	372–468
Step-by-Step	D149...	350–550	350–550	350–550	334–450
Surface Res, ohms	D257...	$10^{13}–10^{14}$	$10^{13}–10^{13}$	$10^{13}–10^{14}$	64×10^{13}
Dielectric Constant					
60 Cycles	D150...	3.5–5.0	3.5–4.5	4.0–4.5	4.4–5.4
1000 Cycles	D150...	3.5–5.0	3.3	3.8–4.1	—
10^6 Cycles	D150...	3.4–4.4	2.6–2.8	3.5–4.0	4.1–4.6
Dissipation Factor					
60 Cycles	D150...	0.001–0.015	0.05	0.005–0.013	—
1000 Cycles	D150...	0.002–0.017	0.04	0.012–0.015	—
10^6 Cycles	D150...	0.015–0.035	0.04	0.012–0.032	—
Loss Factor					
60 Cycles	D150...	0.02–0.07	—	0.022	0.119–0.207
1000 Cycles	D150...	0.02–0.09	—	0.053	—
10^6 Cycles	D150...	0.09–0.13	—	0.12	0.111
Arc Resistance, sec	D495...	65–100	—	65–120	148–180
HEAT RESISTANCE					
Max Rec Svc Temp, F	.....	175	122	400	—
Heat Dist Temp (264 psi), F	D648...	Up to 250	—	Up to 500	210–320
USES		Potting and encapsulation of electrical and electronic components, precision castings, tools and dies, patching compounds			New materials; primary uses probably electrical moldings of all types, such as condensers, switch plates, connector plugs, resistor bobbins and wirewound resistors, molded coils, relay assemblies

[a] Shore A up to 100.
[b] Values cover range obtainable with mineral filler or mineral and glass fiber filler. Compounds designed for compression or transfer molding without release agents. Data, in some cases are preliminary.
[c] 77–140 F. [d] After post-cure.

Fluorocarbons—Molded, Extruded

Type →		Polytrifluorochloroethylene	Polytetrafluoroethylene	Fluorinated Ethylene Propylene
PHYSICAL PROPERTIES	ASTM			
Specific Gravity	D792...	2.10–2.15	2.1–2.3	2.14–2.17
Ther Cond, Btu/hr/sq ft/°F/ft	[a]	0.145	0.14	0.11
Coef of Ther Exp, per °F	D696...	3.88×10^{-5}	5.5×10^{-5}	$8.3–10.5 \times 10^{-5}$
Refractive Index	D542...	1.43	1.35	1.34
Specific Heat, Btu/lb/°F	.....	0.22	0.25	0.28
Transmittance (luminous), %	D791...	80–92	—	—
Water Absorption (24 hr), %	D570...	0.00	0.00	0.00
Flammability	.....	Noninflammable	Noninflammable	Noninflammable
MECHANICAL PROPERTIES				
Mod of Elast in Compression, psi	D638...	1.8×10^5	$0.70–0.90 \times 10^5$	$0.6–0.8 \times 10^5$
Mod of Elast in Tension, psi	D638...	$1.9–3.0 \times 10^5$	$0.38–0.65 \times 10^5$	$0.5–0.7 \times 10^5$
Tensile Strength, 1000 psi	D638...	4.6–5.7	2.5–3.5	2.5–3.5
Elongation (in 2 in.), %	D638...	125–175	250–350	300–900
Hardness (Rockwell)	D785...	R110–115	J75–95	D55
Abrasion Resistance, gm/cycle	[b]	0.0080	—	—
Impact Strength (Izod notched), ft-lb/in.	D256...	3.50–3.62	2.5–4.0	No break
Mod of Elast in Flexure, psi	D747...	$2.0–2.5 \times 10^5$	0.6×10^5	0.8×10^5
Flexural Strength (0.1% offset), 1000 psi	D790...	3.5	1.6	—
Compressive Strength (0.1% offset), 1000 psi	D695...	2.0	0.7–1.8	1.6
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm-cm	D257...	10^{18}	10^{19}	10^{19}
Dielectric Strength (short time), v/mil	D149...	530–600	400–500	500–600
Dielectric Constant				
60 Cycles	D150...	2.6–2.7	2.0	2.1
10^6 Cycles	D150...	2.30–2.37	2.0	2.1
Dissipation Factor				
60 Cycles	D150...	0.02	0.0002	0.0003
10^6 Cycles	D150...	0.007–0.010	0.0002	0.0006
Arc Resistance, sec	.....	>360	>200	>165
FABRICATING PROPERTIES				
Injection Molding				
Pressure, 1000 psi	.....	5–30	—	5–20
Temperature, F	.....	420–620	—	625–760
Compression Molding				
Pressure, 1000 psi	.....	0.1–15	—	1–2
Temperature, F	.....	445–525	—	600–750
Bulk Factor	.....	2.5	—	—
Mold Shrinkage, in./in.	.....	0.005–0.010	—	0.03–0.06
HEAT RESISTANCE				
Max Rec Svc Temp, F	.....	380	500	400
Heat Dist Temp, F				
66 Psi	D648...	196–291	—	—
264 Psi	D648...	151–178	—	—
CHEMICAL RESISTANCE		Impervious to corrosive chemicals; highly resistant to most organic solvents. Swelling may occur with some highly halogenated and aromatic compounds	Inert to most chemicals and solvents with the exception of alkali metals. Halogenated solvents at high temperatures and pressure have some effect	
USES		Chemical pipes, gaskets, pump parts, electrical cables, tank linings, connectors, coil forms, connector inserts, valve diaphragms, electrical insulation	Chemical pipes, valves and valve liners, gaskets and packings, pump bearings and impellers, electrical and electronic equipment, anti-adhesive coatings	Molded electronic and instrument components, valve linings, laminates, corrosion resistant and non-adhesive coatings

[a] Cenco-Fitch.
[b] Federal Spec. L-P-406A, No. 1092.1.

Melamines—Molded

Filler and Type →	ASTM	Alpha Cellulose—General Purpose	Mineral—Electrical	Fabric—Low to Intermediate Shock Resistant	Fabric—Intermediate Resistance
PHYSICAL PROPERTIES					
Specific Gravity	D792...	1.47–1.52	1.7–2.0	1.5	1.5
Ther Cond, Btu/hr/sq ft/°F/ft	.....	0.17–0.24	0.32–0.41	0.257	0.25–0.26
Coef of Ther Exp per °F	D696...	1.11–3.17 x 10^{-5}	1.06–2.50 x 10^{-5}	1.55 x 10^{-5}	1.55 x 10^{-5}
Transmittance (luminous), %	.....	14.5	Opaque	Low	—
Water Absorption (24 hr), %	D570...	0.1–0.6	0.08–0.14	0.3–0.6	0.2–1.3
Flammability	.....	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	D638...	13–16 x 10^5	16–19.5 x 10^5	16 x 10^5	16 x 10^5
Ten Str, 1000 psi	D638...	7–10	5.5–7.0	8–9.5	5.7–9
Elong (in 2 in.), %	D638...	—	0.30–0.45	0.6–0.8	0.6
Hardness (Rockwell)	D785...	M118–124, E110	M110	M120	M115
Impact Str (Izod notched), ft-lb/in.	D256...	0.24–0.35	0.28–0.40	0.5–0.9	1.0–1.5
Mod of Elast in Flex, psi	D790...	15 x 10^5	16 x 10^5	18.5 x 10^5	19 x 10^5
Compr Str, 1000 psi	D695...	40–45	25–30	30–35	25–32
Flex Str, 1000 psi	D790...	10–16	8.7–11	12–15	13–17
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257...	10^{12}–10^{14}	10^{11}–10^{13}	10^9–10^{12}	—
Dielec Str (short time), v/mil	D149...	310–330	350–430	250–350	130–370
Dielec Const					
60 Cycles	D150...	8.4–9.4	6.4–10.2	7.6–8.6	10.5–15.5
10^6 Cycles	D150...	5.6–5.8	6.1–6.7	6.5–6.9	6.1–6.7
Dissip Factor					
60 Cycles	.....	0.05–0.08	0.07–0.17	0.07–0.11	0.10–0.32
10^6 Cycles	.....	0.03–0.04	0.04–0.05	0.036	0.050–0.065
Arc Resistance, sec	D495...	122–128	120–170	115–128	5–8
FABRICATING PROPERTIES					
Bulk Factor	D392...	2.1–3.1	2.1–2.5	5–10	5–10
Compression Molding					
Pressure, 1000 psi	.....	1.5–8	1–7	4–8	4–8
Temperature, F	.....	280–370	275–340	275–330	300–380
Transfer Molding					
Pressure, 1000 psi	.....	4–12	4–20	—	—
Temperature, F	.....	300–320	270–340	—	—
Mold Shrinkage, in./in.	.....	0.006–0.015	0.003–0.007	0.003–0.004	0.004–0.005
HEAT RESISTANCE					
Max Rec Svc Temp, F	.....	210	250–400	250	250
Heat Dist Temp (264 psi), F	D648...	350–410	265	310	375
CHEMICAL RESISTANCE		Resistant to weak acids, weak alkalis, organic solvents, greases and oils. Attacked by strong acids and strong alkalis			
USES		General purpose electrical and mechanical applications such as kitchenware, tableware, lighting fixtures, reflectors	Elevated temperature and electrical applications such as ignition parts, circuit breakers, terminal blocks, electronic parts	Applications requiring improved impact strength, such as insulation, circuit breakers, food trays, medical equipment	Applications requiring medium impact strength, such as nozzles, insulation

Melamines—Molded

Filler and Type →	ASTM	Unfilled	Cellulose Electrical	Glass Fiber	Alpha Cellulose and Mineral
PHYSICAL PROPERTIES					
Specific Gravity	D792...	1.48	1.43–1.50	1.9–2.0	1.49
Ther Cond, Btu/hr/sq ft/°F/ft	.....	—	0.17–0.20	0.28	—
Coef of Ther Exp, per °F	D696...	—	$1.11–2.78 \times 10^{-5}$	0.82×10^{-5}	—
Transmittance (luminous), %	.....	Good	Opaque	—	—
Water Absorption (24 hr), %	D570...	0.3–0.5	0.27–0.80	0.10–0.60	0.5
Flammability	.....	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	D638...	—	$10–11 \times 10^5$	—	—
Ten Str, 1000 psi	D638...	—	5–9	6–10	5
Elong (in 2 in.), %	D638...	—	0.6	—	—
Hardness (Rockwell)	D785...	—	M115–125	—	—
Impact Str (Izod notched), ft-lb/in.	D256...	—	0.27–0.36	4.0–12.0	0.30
Mod of Elast in Flex, psi	D790...	13×10^5	$1.0–1.3 \times 10^5$	—	—
Compr Str, 1000 psi	D695...	40–45	25–33.6	26–32	—
Flex Str, 1000 psi	D790...	11–14	9–10	10–23	8
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257...	—	$10^{12}–10^{13}$	$1–7 \times 10^{11}$	10^{12}
Dielec Str (short time), v/mil	D149...	—	350–400	250–300	375
Dielec Const					
60 Cycles	D150...	—	6.2–7.6	9.7–11.1	—
10^6 Cycles	D150...	—	4.7–7.0	6.9–7.2	6.4
Dissip Factor					
60 Cycles	.....	—	0.019–0.033	0.14–0.23	—
10^6 Cycles	.....	—	0.032–0.06	0.02–0.03	0.031
Arc Resistance, sec	D495...	100–145	95–135	180–186	125
FABRICATING PROPERTIES					
Bulk Factor	D392...	2.0	2.2–2.6	5–7	2.4
Compression Molding					
Pressure, 1000 psi	.....	2–5	1.5–3	2–8	2–5
Temperature, F	.....	300–340	290–360	280–340	280–350
Transfer Molding					
Pressure, 1000 psi	.....	—	6–20	8–20	2–10
Temperature, F	.....	—	300–330	290–310	285–350
Mold Shrinkage, in./in.	.....	0.011–0.012	0.006–0.008	0.001–0.004	0.006–0.007
HEAT RESISTANCE					
Max Rec Svc Temp, F	.....	210	250–280	300–400	275–325
Heat Dist Temp (264 psi), F	D648...	293–298	265	400	300
CHEMICAL RESISTANCE		Resistant to weak acids, weak alkalis, organic solvents, greases and oils. Attacked by strong acids and strong alkalis			
USES		Pearlescent buttons, moldings ornamental applications	General mechanical and electrical applications, particularly at elevated temperatures. Applications requiring improved holding power for metallic inserts such as electrical and electronic parts	Applications requiring high shock resistance, good electrical properties, and high resistance to burning. Switchgear, terminal strips, stand-off insulators, coil forms	Primarily electrical applications requiring low after-shrinkage, good dimensional stability and excellent molding characteristics

Polyamides (Nylons)—Molded, Extruded

Type →		66 Nylon			610 Nylon	
		General Purpose Injection Molding		Extrusion and Injection Molding	Extrusion and Injection Molding	
		0.2% Water	2.5% Water		0.2% Water	1.5% Water
PHYSICAL PROPERTIES	ASTM					
Specific Gravity	D792...	1.14	—	1.14	1.09	—
Ther Cond, Btu/hr/sq ft/°F/ft	[a]	0.14	—	0.142	0.12	—
Coef of Ther Exp, 10^{-5} per °F	D696...	5.5	—	5.5	5.5	—
Spec Ht, Btu/lb/°F	.....	0.3–0.5	—	0.4	0.3–0.5	—
Refractive Index	D542...	1.53	—	—	1.53	—
Water Absorption (24 hr), %	D570...	1.5	—	1.5	0.4	—
Flammability	D757...	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES						
Mod of Elast in Tension, 10^5 psi	D638...	4.1	1.75	4.0	2.8	1.6
Ten Str, 1000 psi	D638...	11.8	11.2	11.2–12.6	8.5	7.1
Elong (in 2 in.), %	D638...	60	300	100–200	85	320
Hardness (Rockwell)	D785...	M79, R118	M59, R108	R118	R111	—
Impact Str (Izod notched), ft-lb/in.	D256...	0.9	2.0	1.1–1.5	0.6	1.6
Mod of Elast in Flex, 10^5 psi	D790...	4.1	1.75	—	2.8	1.6
Flex Yld Str, 1000 psi	D790...	13.8	—	13.8	8	—
Compr Yld Str, 1000 psi	D695...	13	—	—	7.2	—
Compr Yld Str (1% def), 1000 psi	D695...	—	—	4.9	—	—
ELECTRICAL PROPERTIES						
Vol Res, ohm-cm	D257...	—	—	4.5×10^{13}	—	—
Dielec Str (short time), v/mil	D149...	385	—	385	470	—
Dielec Const						
60 Cycles	D150...	4.0	7.6	4.1	3.9	—
10^6 Cycles	D150...	3.6	3.6	3.4	—	—
Dissip Factor						
60 Cycles	D150...	0.01	0.09	0.014	—	—
10^6 Cycles	D150...	0.02	0.08	0.04	0.02	—
Arc Resistance, sec	D495...	—	—	—	—	—
FABRICATING PROPERTIES						
Bulk Factor	D392...	2.1	—	2.14	2.2	—
Injection Molding						
Pressure, 1000 psi	.....	10–20	—	—	10–20	—
Temperature, F	.....	520–650	—	—	450–600	—
Joining	.....	Can be cemented with aqueous phenol or various proprietary adhesives. Spin welding, extrusion lamination and other techniques can be used in special cases				
HEAT RESISTANCE						
Max Rec Svc Temp, F	.....	275–300	—	—	225	—
Heat Dist Temp, F						
66 Psi	D648...	—	—	360	—	—
264 Psi	D648...	—	—	150	—	—
CHEMICAL RESISTANCE		Inert to most organic chemicals such as esters, ketones, alcohols and hydrocarbons. Resist alkalis and salt solutions, but attacked by phenols, formic acid, strong mineral acids and strong oxidizing agents				
USES		Gears, bearings, automatic washing machine valves, rollers and slides, combs and brush backs, aerosol bottles, coil forms, and mechanical parts where lubrication is undesirable or difficult		Tubing, rods, pipe, sheeting, laminations	Jacketing for wire and cable; special molded parts	

[a] Cenco-Fitch.

Polyamides (Nylons)—Molded, Extruded

Type →		6 Nylon		11 Nylon	Soluble Resin (solution, injection, extrusion)	Glass Fiber-Filled[d]
		General Purpose Injection Molding	Extrusion and Injection Molding			
PHYSICAL PROPERTIES	ASTM					
Specific Gravity	D792...	1.13-1.14	1.14	1.1	1.12-1.13	1.30–1.51
Ther Cond, Btu/hr/sq ft/°F/ft	[a]	0.10-0.14	0.11-0.12	—	0.16	0.12
Coef of Ther Exp, 10^{-5} per °F	D696...	4.6-5.4	4.6-7.1	5.5	8.2	1.25–1.7
Spec Ht, Btu/lb/°F	.....	0.4	—	0.58	0.4	0.3–0.35
Water Absorption (24 hr), %	D570...	1.6-2.0	2.1-3.3	0.4	2.0-5.5	0.2-1.4
Flammability	D757...	Self-exting	Self-exting	Self-exting	Self-exting	Self-exting
MECHANICAL PROPERTIES						
Mod of Elast in Tension, 10^5 psi	D638...	2.5-3.4	1.5-3.6	1.8-1.9	0.38	1.2–8.6
Ten Str, 1000 psi	D638...	10.2-12	10.2-11.3	8.5	3.8-7.4	19–31
Elong (in 2 in.), %	D638...	300	300	100-120	300-600	1.5–2.3
Hardness (Rockwell)	D785...	R105-118	R103-111	A50-55	R45-83	E64–79
Impact Str (Izod notched), ft-lb/in.	D256...	1.2-3.0	1.5-3.5	3.3-3.6	>16	2.5–5.0
Flex Yld Str, 1000 psi	D790...	15.5	—	—	1-2	21–40
Compr Yld Str (1% def), 1000 psi	D695...	7.1-9.7	6.7-8.8	—	0.8	15–25
ELECTRICAL PROPERTIES						
Vol Res, ohm-cm	D257...	10^{13}-10^{15}	10^{13}-10^{15}	2×10^{13}	5×10^{13}	$1.5\text{-}5.5 \times 10^{15}$
Dielec Str (short time), v/mil	D149...	420-485	440-500	425	420	400–500
Dielec Const						
60 Cycles	D150...	4.5-11.5	5.1-14.0	3.3[e]	10.7	4.0–4.6
10^6 Cycles	D150...	3.6-4.3	3.5-4.5	—	4.5	3.4–3.9
Dissip Factor						
60 Cycles	D150...	0.03-0.07	0.06-0.10	0.03	0.19	0.018–0.026
10^6 Cycles	D150...	0.03-0.13	0.03-0.11	0.02	0.14	0.17–0.22
Arc Resistance, sec	D495...	—	—	—	—	90–150
FABRICATING PROPERTIES						
Bulk Factor	D392...	1.60-1.68	1.72-1.82	2.2	2.5	2.0
Compression Molding						
Pressure, 1000 psi	.....	—	—	—	1-2	—
Temperature, F	.....	—	—	—	325-380	—
Injection Molding						
Pressure, 1000 psi	.....	10-25	—	—	10-25	10-25
Temperature, F	.....	440-550	—	—	300-500	500-650
Extruding Temp, F	.....	450-550	430-550	—	500-550	—
Joining	.....	Nylon adhesive or aqueous phenol		—	[b]	Same as nylon
HEAT RESISTANCE						
Max Rec Svc Temp, F	.....	225-250	200-250	212-250	140	300–400
Heat Dist Temp, F						
66 Psi	D648...	340	—	—	100	430–540
264 Psi	D648...	145	—	—	—	425–530
CHEMICAL RESISTANCE		Resists esters, ketones, alkalis, weak acids, alcohols and common solvents. Not resistant to conc mineral acids	Resists petroleum oils and greases, alkalis, esters, ketones, alcohols and common solvents. Not resistant to mineral acids	Similar to other nylons	Resists ketones, alkalis and esters. Not resistant to alcohols, phenols, formic acid, and mineral acids	Attacked by strong acids. Fairly resistant to strong alkalis. Resists common solvents
USES		Bearings, gears, bushings, coil forms, brush backs, rod, tubing, tape	Abrasion resistant shielding oninsulated wire and mechanical cable. Pipe, tubing	Electrical insulation and other nylon uses where low moisture absorption is needed	Jacketing for wire and cable, seals, packings, sheeting, adhesives, abrasion-resistant finishes	Gears, business machine parts, bearing cages, mechanical components

[a] Cenco-Fitch.
[b] Can be bonded with 70-30 methanol-water as cement, or 10% solution of resin in methanol-water as solvent.
[d] Covers range obtainable in 10 grades.
[e] At 1000 cps.

Phenolics—Molded

Type and Filler →	ASTM	General—Woodflour and Flock	Shock—Paper, Flock or Pulp	High Shock—Chopped Fabric or Cord	Very High Shock—Glass Fiber
PHYSICAL PROPERTIES					
Specific Gravity	D792	1.32–1.55	1.34–1.46	1.36–1.43	1.75–1.90
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.097–0.3[a]	0.1–0.16	0.097–0.170	0.20[a]
Coef of Ther Exp, 10^{-5} per °F	D696	1.66–2.50	1.6–2.3	1.60–2.22	0.88
Spec Ht, Btu/lb/°F		0.35–0.40	—	0.30–0.35	0.28–0.32
Water Absorption (24 hr), %	D570	0.3–0.8	0.4–1.5	0.4–1.75	0.1–1.0
Flammability	D635	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES					
Mod of Elast in Tension, 10^5 psi	D638	8–13	8–12	9–14	30–33
Ten Str, 1000 psi	D638, D651	5.0–8.5	5.0–8.5	5–9	5–10
Elong (in 2 in.), %	D638	0.4–0.8	—	0.37–0.57	0.2
Hardness (Rockwell)	D785	M108–120	—	M93–120	M95–100
Impact Str (Izod notched), ft-lb/in.	D256	0.24–0.50	—	0.6–8.0	10–33
Mod of Elast in Flex, 10^5 psi	D790	8–12	—	9–13	—
Flex Str, 1000 psi	D790	8.5–12	8.0–11.5	8–15	10–45
Compr Str, 1000 psi	D695	22–36	24–35	15–30	17–30
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	10^9–10^{13}	1–50 x 10^{11}	>10^{10}	7–10 x 10^{12}
Dielec Str (short time), v/mil	D149	200–425	250–350	200–350	200–370
Dielec Const					
60 Cycles	D150	5.0–9.0	5.6–11.0	6.5–15.0	7.1–7.2
10^6 Cycles	D150	4.0–7.0	4.5– 7.0	4.5– 7.0	4.6–6.6
Dissip Factor					
60 Cycles	D150	0.05–0.30	0.08–0.35	0.08–0.45	0.02–0.03
10^6 Cycles	D150	0.03–0.07	0.03–0.07	0.03–0.09	0.02
Arc Resistance, sec	D495	5–60	5–60	5–60	60
FABRICATING PROPERTIES					
Bulk Factor		2.1–4.4	2.3–5.7	3.0–18.0	6.1–6.3
Compression Molding					
Pressure, 1000 psi		1.5–5.0	2–5	2–6.5	1–5
Temperature, F		290–380	290–380	280–380	500–5000
Transfer Molding					
Pressure, 1000 psi		2–10	2–10	2–12	—
Temperature, F		275–340	275–340	275–340	—
Mold Shrinkage, in./in.		0.005–0.008	0.004–0.009	0.002–0.009	0.0
HEAT RESISTANCE					
Max Rec Svc Temp, F		300–350	300	250–275	350–450
Heat Dist Temp, F	D648	260–340	290–340	250–340	600
CHEMICAL RESISTANCE		Severely attacked by strong acids and strong alkalis. Effects of dilute acids, alkalis and organic solvents vary with the reagent. Chemical resistance varies with the particular formulation and not all materials of a type are equally resistant			
USES		Mechanical applications include pulleys, wheels, motor housings, handles. Electrical uses include coil forms, ignition parts, condenser housings, fuse blocks, instrument panels. Thermal applications include handles, appliance connector plugs. Chemical uses include photographic development tanks, rayon spinning buckets and parts, milking machine cups. Decorative uses include radio and television cabinets, handles, knobs, buttons			

[a] Cenco-Fitch.

Phenolics—Molded

Type and Filler →		High Frequency—Mineral	Shock & Heat—Mineral, Flour and Yarn	Heat—Mineral	Chemical (no filler)
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792...	1.75–1.92	1.68–2.00	1.54–1.75	1.24–1.90
Ther Cond, Btu/hr/sq ft/°F/ft	C177...	0.24–0.34	0.19–0.39	0.19–0.39	—
Coef of Ther Exp, 10^{-5} per °F	D696...	1.05–1.44	0.83–1.17	1.17	2.4
Spec Ht, Btu/lb/°F	.....	0.28–0.32	0.28–0.32	0.28–0.32	—
Water Absorption (24 hr), %	D570...	0.01–0.07	0.1–0.5	0.2–0.5	0.15–0.60
Flammability	D635...	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES					
Mod of Elast in Tension, 10^5 psi	D638...	30–50	15–25	10–20	7–15
Ten Str, 1000 psi	D638, D651...	5–7	4–9	4–6.5	4.5–7.5
Elong (in 2 in.), %	D638...	0.10–0.53	—	—	—
Hardness (Rockwell)	D785...	M100–110	M100–110	M98–115	M105–120
Impact Str (Izod notched), ft-lb/in.	D256...	0.30–0.38	0.27–3.50	0.24–0.40	0.2–0.6
Mod of Elast in Flex, 10^5 psi	D790...	30–40	10–25	10–20	7–15
Flex Str, 1000 psi	D790...	8–12	7–15	3–10.5	7–12
Compr Str, 1000 psi	D695...	15–25	15–25	15–35	18–32
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257...	10^{13}	10^{10}–10^{12}	10^{11}–10^{12}	10^{11} - 10^{13}
Dielec Str (short time), v/mil	D149...	300–375	100–250	150–350	225–275
Dielec Const					
60 Cycles	D150...	4.7–5.5	30–150	5.8–40.0	9–19
10^6 Cycles	D150...	4.4–5.1	5–7	4.8– 8.0	5.5–7.0
Dissip Factor					
60 Cycles	D150...	0.01–0.07	0.25–0.50	0.10–0.35	0.15–0.25
10^6 Cycles	D150...	0.005–0.02	0.10–0.50	0.04–0.15	0.04–0.09
Arc Resistance, sec	D495...	16	6–180	5–180	—
FABRICATING PROPERTIES					
Bulk Factor	.....	2.1–2.7	3–14	2.0–2.8	1.9–3.0
Compression Molding					
Pressure, 1000 psi	.....	2.0–5.5	2–6	2–6	2–6
Temperature, F	.....	300–350	290–380	290–380	300–360
Transfer Molding					
Pressure, 1000 psi	.....	2–10	2–12.	2–9	2–10
Temperature, F	.....	275–325	275–325	275–325	275–340
Mold Shrinkage, in./in.	.....	0.003	0.0005–0.005	0.002–0.006	0.002–0.01
HEAT RESISTANCE					
Max Rec Svc Temp, F	.....	250–300	350–400	375–425	300–425
Heat Dist Temp, F	D648...	230–325	290–375	350–400	300–350
CHEMICAL RESISTANCE		Severely attacked by strong acids and strong alkalis. Effects of dilute acids, alkalis and organic solvents vary with the reagent. Chemical resistance varies with the particular formulation and not all materials of a type are equally resistant			
USES		Mechanical applications include pulleys, wheels, motor housings, handles. Electrical uses include coil forms, ignition parts, condenser housings, fuse blocks, instrument panels. Thermal applications include handles, appliance connector plugs. Chemical uses include photographic development tanks, rayon spinning buckets and parts, milking machine cups. Decorative uses include radio and television cabinets, handles, knobs, buttons			

continued on next page

Phenolics—Molded

Type and Filler →	ASTM	Arc Resistant—Mineral	Rubber Phenolic—Woodflour or Flock	Rubber Phenolic—Chopped Fabric	Rubber Phenolic—Asbestos
PHYSICAL PROPERTIES					
Specific Gravity	D792...	1.8–3.0	1.24–1.35	1.30–1.35	1.60–1.65
Ther Cond, Btu/hr/sq ft/°F/ft	C177...	0.24–0.34	0.12	0.05	0.04
Coef of Ther Exp, 10^{-5} per °F	D696...	—	0.83–2.20	1.7	2.2
Spec Ht, Btu/lb/°F	.....	0.28–0.32	0.33	—	—
Water Absorption (24 hr), %	D570...	0.2	0.5–2.0	0.5–2.0	0.10–0.50
Flammability	D635...	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES					
Mod of Elast in Tension, 10^5 psi	D638...	—	4–6	3.5–6	5–9
Ten Str, 1000 psi	D638, D651...	6	4.5–9	3.5	4
Elong (in 2 in.), %	D638...	—	0.75–2.25	—	—
Hardness (Rockwell)	D785...	—	M40–90	M57	M50.
Impact Str (Izod notched), ft-lb/in.	D256...	0.32	0.34–1.0	2.0–2.3	0.3–0.4
Mod of Elast in Flex, 10^5 psi	D790...	—	4–6	3.5	5.0
Flex Str, 1000 psi	D790...	10	7–12	7	7
Compr Str, 1000 psi	D695...	20	12–20	10–15	10–20
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257...	6×10^{12}	10^8–10^{11}	10^{11}	10^{11}
Dielec Str (short time), v/mil	D149...	380	250–375	250	350
Dielec Const					
60 Cycles	D150...	7.4	9–16	15	15
10^6 Cycles	D150...	—	5	5	5
Dissip Factor					
60 Cycles	D150...	—	0.15–0.60	0.5	0.15
10^6 Cycles	D150...	0.10	0.1–0.2	0.09	0.13
Arc Resistance, sec	D495...	180	7–20	10–20	5–20
FABRICATING PROPERTIES					
Bulk Factor	.....	2.4	2.5–4.0	4.6–8.0	2.5
Compression Molding					
Pressure, 1000 psi	.....	2–5	2–6	2–6	2–6
Temperature, F	.....	285–350	300–360	300–350	300–350
Transfer Molding					
Pressure, 1000 psi	.....	2–10	2–12	2–12	2–12
Temperature, F	.....	285–350	300–350	300–350	300–350
Mold Shrinkage, in./in.	.....	0.004	0.005–0.010	0.003–0.006	0.005–0.008
HEAT RESISTANCE					
Max Rec Svc Temp, F	.....	400	212–300	212–225	225–260
Heat Dist Temp, F	D648...	335	220–270	220–280	250–300
CHEMICAL RESISTANCE		Severely attacked by strong acids and strong alkalis. Effects of dilute acids, alkalis and organic solvents vary with the reagent. Chemical resistance varies with the particular formulation and not all materials of a type are equally resistant			
USES		Mechanical applications include pulleys, wheels, motor housings, handles. Electrical uses include coil forms, ignition parts, condenser housings, fuse blocks, instrument panels. Thermal applications include handles, appliance connector plugs. Chemical uses include photographic development tanks, rayon spinning buckets and parts, milking machine cups. Decorative uses include radio and television cabinets, handles, knobs, buttons			

Phenolics—Cast

Type →		Type I—Mechanical and Chemical	Type II—General Purpose Decorative	Type III—General Purpose Transparent
PHYSICAL PROPERTIES	ASTM			
Specific Gravity	D792...	1.31	1.32	1.33
Coef of Ther Exp, per °F	D696...	3.3–4.4 x 10^{-5}	3.3–5.5 x 10^{-5}	4.7–6.6 x 10^{-5}
Water Absorption (24 hr), %	D570...	0.35–0.40	0.32–0.35	0.3–2.0
Flammability (>0.050 in.)	D635...	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	D638...	4–5 x 10^5	3–4.5 x 10^5	1–3 x 10^5
Tensile Strength, 1000 psi	D638...	6–9	5–7.2	2.5–4.5
Hardness (Rockwell)	D785...	M93–120	M90–105	R98–120
Impact Strength (Izod notched), ft-lb/in	D256...	0.25–0.40	0.30–0.45	0.23–0.35
Mod of Elast in Flexure, psi	D790...	3–5 x 10^5	3–5 x 10^5	1–3 x 10^5
Flexural Strength, 1000 psi	D790...	11–17	10–15	4–7
Compressive Yield Strength (1% offset), 1000 psi	D695...	14–18	12.8–15.8	4.5–6.5
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm-cm	D257...	1–7 x 10^{12}	1–3 x 10^{12}	3 x 10^{11}
Dielectric Strength (short time), v/mil	D149...	350–400	300–450	75–250
Dielectric Constant				
60 Cycles	D150...	6.5–7.5	15–20	20–30
10^6 Cycles	D150...	4.0–5.5	5.0–11.0	7–8
Loss Factor				
60 Cycles	D150...	0.05–0.9	0.4–4.0	5.0–17.0
10^6 Cycles	D150...	0.15–0.35	0.05–1.10	0.6–0.8
FABRICATING PROPERTIES	—	Castings produced by pouring resins into molds (generally made of lead). Resins converted to solid by heating several days at atmospheric pressure and temperatures below 212 F. After oven baking, casting is removed from mold and is ready for machining and polishing		
HEAT RESISTANCE				
Heat Dist Temp, F				
66 Psi	D648...	—	150–160	125–135
264 Psi	D648...	165–175	130–140	100–125
CHEMICAL RESISTANCE		Unless specially formulated, do not resist strong alkalis or strong acids. Dilute alkalis: slight to marked attack depending on alkali. Dilute acids: no effect or slight decomposition depending on acid. Continuous immersion in acetone, Cellosolve, methyl alcohol or ethyl alcohol results in noticeable attack, depending on time, temperature and hardness of cast resin		
USES		Drill and saw jigs, stretch press molds and dies for fabricating aircraft parts, furniture hardware, instrument casings, sporting goods, costume and ornamental jewelry		

Polyesters—Cast

Type →		Allyl Type	Rigid Styrene Type	Nonrigid Styrene Type
PHYSICAL PROPERTIES	ASTM			
Specific Gravity	D792...	1.30–1.45	1.12–1.46	1.06–1.25
Ther Cond, Btu/hr/sq ft/°F/ft	C177...	0.116–0.121	0.10–0.12	—
Coef of Ther Exp, per °F	D696...	2.8–5.6 x 10^{-5}	3.9–5.6 x 10^{-5}	—
Refractive Index	D542...	1.50–1.58	1.53–1.58	1.50–1.57
Specific Heat, Btu/lb/°F	.....	0.26–0.55	0.30–0.55	—
Water Absorption (24 hr), %	D570...	0.03–1.0	0.15–0.60	0.40–2.5
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	D638...	2–3 x 10^5	1.5–6.5 x 10^5	—
Tensile Strength, 1000 psi	D638...	4.5–7	4–10	0.9–1.9
Elongation (in 2 in.), %	D638...	—	<5	40–310
Hardness (Rockwell)	D785...	M92–118	M65–115	—
Impact Strength (Izod notched), ft-lb/in.	D256...	0.18–0.32	0.18–0.40	>7.0
Mod of Elast in Flexure, psi	.....	3–8 x 10^5	3–9 x 10^5	0.001–0.1 x 10^5
Flexural Strength, 1000 psi	D790...	6–14	7–19	—
Compressive Strength, 1000 psi	D695...	20–26	12–37	—
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm-cm	D257...	>10^{13}	>10^{13}	>10^{12}
Dielectric Strength (short time), v/mil	D149...	330–500	340–570	220–400
Dielectric Constant				
60 Cycles	D150...	3.2–5.2	2.8–4.4	4.2–7.0
10^6 Cycles	D150...	3.3–4.8	2.8–4.0	3.7–6.1
Dissipation Factor				
60 Cycles	D150...	0.006–0.02	0.003–0.04	0.02–0.18
10^6 Cycles	D150...	0.024–0.045	0.006–0.04	0.02–0.06
Arc Resistance, sec	D495...	120–150	115–135	125–145
HEAT RESISTANCE				
Max Rec Svc Temp, F	D648...	300	250–300	200–250
Heat Dist Temp, F	.....	120–320	120–420	250
CHEMICAL RESISTANCE		Attacked by oxidizing acids. Slightly attacked by strong alkalis. Resistant to organic solvents	Slightly to heavily attacked by strong acids. Attacked by strong alkalis, ketones and chlorinated solvents	
USES		Castings used for aircraft glazing, electrical components, decorative applications. Resins used for premix and prepreg molding materials, matched metal molding and hand lay-up molding		

Silicones—Molded

Type and Filler →		General—Mineral	Improved Impact—Glass Fiber	High Impact—Glass Fiber
PHYSICAL PROPERTIES	ASTM			
Specific Gravity	D792	1.8–2.0	1.8–2.0	1.65–2.00
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.089–0.097	0.089–0.097	0.089–0.097
Coef of Ther Exp, per °F	D696	2.78–3.23 x 10^{-5}	3.17–3.23 x 10^{-5}	0.45 x 10^{-5}
Water Absorption (24 hr), %	D570	0.1–0.15	0.1–0.15	0.1–0.15
Flammability, ipm	D635	0–78	0–60	25–100
MECHANICAL PROPERTIES				
Tensile Strength, 1000 psi	D651	4–4.3	4–4.3	4.4–5
Hardness (Rockwell)	D785	M89	M89	M85
Impact Strength (Izod notched), ft-lb/in.	D256	0.25–0.30	0.33–0.38	15.0–20.0
Mod of Elast in Flexure, psi	D790	10–13 x 10^5	9–11 x 10^5	15–19 x 10^5
Flexural Strength, 1000 psi	D790	6.8–7.5	10–14	10–14
Compressive Strength, 1000 psi	D695	16–20	12–16	10–15
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm-cm	D257	>3.4 x 10^{13}	>3.4 x 10^{13}	>5 x 10^{13}
Dielectric Strength (short time), v/mil	D149	350–400	300–400	250–400
Dielectric Constant				
60 Cycles	D150	4.1–4.5	4–5	4–5
10^6 Cycles	D150	3.8–4.3	4–5	3.6–5.1
Dissipation Factor				
60 Cycles	D150	0.010–0.014	0.008–0.011	0.006–0.030
10^6 Cycles	D150	0.006–0.010	0.007–0.011	0.005–0.020
Arc Resistance, sec	D495	250–420	100–350	100–350
Loss Factor				
60 Cycles	D150	0.041–0.063	0.041–0.058	0.029–0.035
10^6 Cycles	D150	0.023–0.043	0.034–0.056	0.025–0.077
FABRICATING PROPERTIES				
Bulk Factor		2.1–2.6	2.3–2.8	6–9
Compression Molding				
Pressure, 1000 psi		2–4	2–4	1–5
Temperature, F		300–350	300–350	300–350
Transfer Molding				
Pressure, 1000 psi		3.5–15	3.5–15	4.5–15
Temperature, F		300–350	300–350	300–350
Mold Shrinkage, in./in.		0.006–0.010	0.005–0.008	0.003–0.005
HEAT RESISTANCE				
Max Res Svc Temp, F		> 700	> 600	> 600
Heat Dist Temp, F	D648	> 900	> 900	> 900
CHEMICAL RESISTANCE		Resistant to aviation gasoline, lubricating oil, and sulfuric and hydrochloric acids. Slightly softened and pitted by sodium hydroxide, except some of the mineral-filled materials. Should be tested if resistance to ketones, toluene, ethylenes, etc., is required		
USES		Motor slot wedges, terminal boards, connector plugs, switches and insulators, aircraft brake assemblies, jet engine parts, aircraft ignition systems, guided missile parts, tube bases and caps		

Polystyrenes and Modified Polystyrenes—Molded, Extruded

Type →		Polystyrene		Modified Polystyrene		
		General Purpose	Glass Fiber-Filled	Heat & Chemical Resistant	Medium-High Impact*	Extra High Impact
PHYSICAL PROPERTIES	ASTM					
Specific Gravity	D792	1.04–1.07	1.25–1.32	1.05–1.11	1.04–1.08	1.0–1.10
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.058–0.080	—	0.046–0.072	0.024–0.072	0.024–0.073
Coef of Ther Exp, 10^{-6} per °F	D696	3.3–4.4	2.2–2.4	3.8	3.3–4.7	2.2–5.6
Spec Ht, Btu/lb/°F		0.32–0.35	0.24–0.27	0.32–0.35	0.30–0.35	0.30–0.35
Refractive Index	D542	1.58–1.60	—	1.58–1.60	—	—
Transmittance (luminous), %		0–93	—	—	—	—
Water Absorption (24 hr), %	D570	0.03–0.05	0.05–0.07	0.1–0.3	0.03–0.08	0.05–0.20
Flammability, ipm	D635	1.0–1.5	—	0.4–0.7	0.5–2.0	0.5–2.0
MECHANICAL PROPERTIES						
Mod of Elast in Tension, 10^5 psi	D638	4–5	11–13	4–6	3.0–4.5	2.5–4.0
Ten Str, 1000 psi	D638	5–8	11–17	10–11	3.5–6.8	3.0–5.5
Elong (in 2 in.), %	D638	1.5–2.4	1.1–1.3	1–3	5–35	15–45
Hardness (Rockwell)	D785	M68–80	M90–100	M78–88	M15–80	M15–60
Impact Str (Izod), ft-lb/in. notch	D256	0.25–0.35	1.4–6.1	0.25–0.50	0.6–3.0	6–11
Mod of Elast in Flex, 10^5 psi		4–5	11–13	4–6	3–5	2.3–4.0
Flex Str, 1000 psi	D790	8–15	15–24	11–17	No failure	No failure
Compr Str, 1000 psi	D695	11.5–16	14–20	12–17	—	—
ELECTRICAL PROPERTIES						
Vol Res, ohm-cm	D257	10^{18}–10^{19}	3.5 x 10^{16}	10^{13}–10^{17}	10^{14}–10^{16}	10^{12}–10^{17}
Dielec Str (short time), v/mil	D149	>500	320–425	400–600	>450	300–650
Dielec Const						
60 Cycles	D150	—	2.95–3.50	2.7–3.4	2.45–2.70[d]	2.5–4.0
10^6 Cycles	D150	2.45–2.65	2.74–3.41	2.7–3.1	—	2.5–4.0
Dissip Factor						
60 Cycles	D150	—	0.005–0.014	0.001–0.008	0.0004–0.01[d]	—
10^6 Cycles	D150	0.0001–0.0005	0.00125–0.0028	0.001–0.008	—	—
FABRICATING PROPERTIES						
Bulk Factor		1.6–2.3	—	1.6–2.3	1.6–2.3	1.6–2.3
Compression Molding						
Pressure, 1000 psi		1–7.5	2–5	1–5	1–8	1–8
Temperature, F		275–400	275–350	325–450	325–475	300–450
Injection Molding						
Pressure, 1000 psi		10–24	15–20	10–24	10–24	10–30
Temperature, F		325–650	450–600	400–700	300–600	375–550
Mold Shrinkage, in./in.		0.002–0.008	0.001–0.003	0.002–0.008	0.002–0.008	0.002–0.0
HEAT RESISTANCE						
Max Rec Svc Temp, F		140–160[a]	190–200	175–190	125–165	120–160
Heat Dist Temp (264 psi), F	D648	165–190[b]	145–220	200–220	155–180	185–190
CHEMICAL RESISTANCE		Good resistance to alkalis, salts, lower alcohols, glycols, water. Fair resistance to mineral and vegetable oils. Soluble in aromatic and chlorinated hydrocarbons. Softened or attacked by higher alcohols, gasoline, strong oxidizing acids, chlorine		More resistant to attack by solvents, oils and other organic liquids than other polystyrenes	Similar to general purpose polystyrene	
USES		Electrical parts, incl storage battery cases, insulators, coil forms. Fluorescent light fixtures, rigid containers, instrument panels, nameplates, refrigerator parts, housewares, toys	Magnetic tape reels, housings and covers, yarn bobbins, structural support members, instrument panels, storage battery cases	Battery cases, coil forms, drafting instruments, sight glasses on pressure lubricating systems, thermostat housings	Coat hangers; toilet seats; refrigerator door panels, drawers and crispers; knobs; toys; vacuum formed sheet	Freezer lids, action toys, children's furniture

[a] 160–180 F for heat resistant grades.
[b] 180–205 F for heat resistant grades.
* Covers values obtainable in both Medium and High Impact grades.
[d] Average for wide frequency range.

ABS Resins and Methylstyrenes—Molded, Extruded

Type →		ABS Resins			Methylstyrene[b]	
		Medium–High Impact[a]	Extra–High Impact	Low Temp Impact	Polymethyl–styrene	Methylstyrene–Acrylonitrile
PHYSICAL PROPERTIES	ASTM					
Specific Gravity	D792...	1.04–1.06	1.01–1.06	1.02	1.01–1.03	1.06
Ther Cond, Btu/hr/sq ft/°F/ft	C177...	0.08–0.12	0.08–0.12	0.08–0.12	—	—
Coef of Ther Exp, 10^{-4} per °F	D696...	4.7	4.7–5.6	4.7–5.6	—	—
Spec Ht, Btu/lb/°F	.....	0.35–0.38	0.35–0.38	0.35–0.38	—	—
Refractive Index	D542...	—	—	—	1.581	1.559
Transmittance (luminous), %	.....	—	—	—	Transparent	Transparent
Water Absorption (24 hr), %	D570...	0.2	0.3	0.2	0.05	0.31
Flammability, ipm	D635...	1.3	1.3	1.3	Slow	Slow
MECHANICAL PROPERTIES						
Mod of Elast in Tension, 10^5 psi	D638...	2.6–2.9	2.1–2.6	1.0	—	—
Ten Str, 1000 psi	D638...	4.5–8.5	5–8	3–4	6.6–8.9	9.3
Elong (in 2 in.), %	D638...	5–100	20–50	30–200	2.2–5.0	2.5
Hardness (Rockwell)	D785...	R85–118	R85–100	R30–65	M76–83	M83
Impact Str (Izod), ft-lb/in. notch	D256...	0.5–6.0	5–9	6–10	0.33	0.40
Mod of Elast in Flex, 10^5 psi	.....	37–45	—	—	4.0	4.6
Flex Str, 1000 psi	D790...	7.5–11.0	6.8–8.0	3–4	10–13	16
Compr Str, 1000 psi	D695...	—	—	—	—	—
ELECTRICAL PROPERTIES						
Vol Res, ohm-cm	D257...	$>8 \times 10^{13}$	1.8×10^{13}	$8.2–0.5 \times 10^{13}$	$2.6–5000 \times 10^{14}$	2.65×10^{11}
Dielec Str (short time), v/mil	D149...	350–416	312	340–416	890–1950	610
Dielec Const						
60 Cycles	D150...	2.7–4.2	2.7–4.76	2.7–4.0	—	—
10^6 Cycles	D150...	2.8–3.6	3.78	2.8–4.1	2.48	2.81
Dissip Factor						
60 Cycles	D150...	0.009–0.015	0.021	0.01	—	—
10^6 Cycles	D150...	0.017–0.026	0.026	0.02	0.0006	0.0078
FABRICATING PROPERTIES						
Bulk Factor	.....	2.25–2.27	2.29	2.27	—	—
Compression Molding						
Pressure, 1000 psi	.....	>1	>1	>1	1–8	1–8
Temperature, F	.....	325–375	325–375	325–375	300–375	300–375
Injection Molding						
Pressure, 1000 psi	.....	6–30	6–30	6–30	10–30	10–30
Temperature, F	.....	350–600	375–600	350–600	400–550	400–550
Mold Shrinkage, in./in.	.....	0.001–0.010	0.001–0.010	0.001–0.010	0.0046	0.0035
HEAT RESISTANCE						
Max Rec Svc Temp, F	.....	—	—	—	210	212
Heat Dist Temp (264 psi), F	D648...	185–215	185	175–185	213–216	215
CHEMICAL RESISTANCE		Highly resistant to aqueous acids, alkalis, salts. Resistant to concentrated phosphoric and hydrochloric acids, alcohols, and animal, vegetable and mineral oils. Disintegrated by concentrated sulfuric and nitric acids. Soluble in esters, ketones, ethylene dichloride			Same as polystyrenes	Resists aliphatic hydrocarbons, gasoline, essential oils, vegetable and mineral oils
USES		Pipe, appliance housings and wheels, protective sportswear, housewares, howitzer cartridges			Radio cabinets, housewares and household utility parts, refrigerator parts, decorative lighting, packaging, electronic components	Same as polymethylstyrene. Also metering sight glasses, fan blades, combs, automotive interior parts, machine housings

[a] Range covers values obtainable in both Medium and High Impact grades.
[b] Recently withdrawn from commercial production.

Polyethylenes—Molded, Extruded

Type →		Type I—Lower Density (0.910–0.925)			Type II—Medium Density (0.926–0.940)	
		Melt Index 0.3-3.6	Melt Index 6-26	Melt Index 200	Melt Index 12.0	Melt Index 1.0-1.9
PHYSICAL PROPERTIES	ASTM					
Specific Gravity	D792	0.910–0.925	0.918–0.925	0.910	0.930	0.930–0.940
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.19	0.19	0.19	0.19	0.19
Coef of Ther Exp, 10^{-5} per °F	D696	8.9–11.0	8.9–11.0	11.0	8.3–16.7	8.3–16.7
Refractive Index	D542	1.51	1.51	1.51	1.51	1.51
Spec Ht, Btu/lb/°F		0.53–0.55	0.53–0.55	0.53–0.55	0.53–0.55	0.53–0.55
Water Absorption (24 hr), %	D570	<0.01	<0.01	<0.01	<0.01	<0.01
Flammability, ipm	D635	1.0	1.0	1.0	1.0	1.0
MECHANICAL PROPERTIES						
Mod of Elast in Tension, 10^5 psi	D638	0.21–0.27	0.20–0.24	—	—	—
Ten Str, 1000 psi	D412	1.4–2.5	1.4–2.0	0.9–1.1	2.0	2.3–2.4
Elong (in 2 in.), %	D412	500–725	125–675	80–100	200	200–425
Hardness (Shore)	D785	C73, D50–52	C73, D47–53	D45	D55	D55–D56
Impact Str (Izod), ft-lb/in. notch	D256	—	—	—	—	—
Brittleness Temp, F		<−94	<−4	<14	<−148	<−148
Mod of Elast in Flex, 10^5 psi	D747	13–27	12–30	10	43	35–50
Shear Str, 1000 psi		1.6–1.85	1.4–1.7	1	—	—
ELECTRICAL PROPERTIES						
Vol Res, ohm-cm	D257	10^{17}–10^{19}	10^{17}–10^{19}	10^{17}–10^{19}	$>10^{16}$	$>10^{16}$
Dielec Str (short time), v/mil	D149	480	480	480	480	480
Dielec Const	D150	2.3	2.3	2.3	2.3	2.3
Dissip Factor	D150	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
FABRICATING PROPERTIES						
Bulk Factor		1.6–2.2	1.6–2.2	1.6–2.2	1.6–2.2	1.6–2.2
Injection Molding						
Pressure, 1000 psi		5–22	5–15	2–10	10–15	10–15
Temperature, F		275–650	275–650	250–350	300–500	300–500
Mold Shrinkage, in./in.		0.02–0.05	0.01–0.04	0.01–0.02	0.02–0.05	0.02–0.05
HEAT RESISTANCE						
Vicat Softening Point, F		176–201	176–201	—	215	220–235
CHEMICAL RESISTANCE		Excellent resistance to acids and alkalis at normal temperature, except oxidizing acids such as nitric, chlorosulfonic and fuming sulfuric. Below 122 F, insoluble in organic solvents; at higher temperatures, soluble to varying degrees in hydrocarbons and halogenated hydrocarbons, but insoluble in more polar liquids. Generally, a higher melt index material has greater solubility				
USES		Injection moldings: kitchen utilityware, toys, process tank liners, closures, packages, sealing rings, battery parts. Blow moldings: squeeze bottles for packaging, containers for drugs. Film: wrapping materials for food, clothes, other items. Wire and cable: high frequency insulation, jacketing. Pipe: chemicals handling, irrigation systems, natural gas transmission				

Polyethylenes—Molded, Extruded

Type →		Type III—Higher Density (0.942–0.960)			
		Melt Index 0.2-0.6	Melt Index 0.1-12.0	Melt Index 1.5-5.0	Melt Index 0.2-0.9
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792	0.942–0.947	0.950–0.955	0.96	0.96
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.19	0.19	0.19	0.19
Coef of Ther Exp, 10^{-5} per °F	D696	8.3–16.7	8.3–16.7	8.3–16.7	8.3–16.7
Refractive Index	D542	1.54	1.54	1.54	1.54
Spec Ht, Btu/lb/°F		0.46–0.55	0.46–0.55	0.46–0.55	0.46–0.55
Water Absorption (24 hr), %	D570	<0.01	<0.01	<0.01	<0.01
Flammability, ipm	D635	1.0	1.0	1.0	1.0
MECHANICAL PROPERTIES					
Mod of Elast in Tension, 10^5 psi	D638	—	—	—	—
Ten Str, 1000 psi	D412	—	2.9–4.0	4.4	4.4
Elongation, %	D412	—	25–400	12–20	25–30
Hardness (Shore)	D785	D65–66	D60–70	D68–70	D68–70
Impact Str (Izod), ft-lb/in. notch	D256	1.5–6	0.4–6.0	1.2–2.5	4.0–14
Brittleness Temp, F		<−76	<−76 to <−170	−100 to −180	−106 to −180
Mod of Elast in Flex, 10^5 psi	D747	85–120	90–125	150	130–150
Shear Str, 1000 psi		—	—	—	—
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	$>10^{16}$	$>10^{16}$	$>10^{16}$	$>10^{16}$
Dielec Str (short time), v/mil	D149	480	480	480	480
Dielec Const	D150	2.3	2.3	2.3	2.3
Dissip Factor	D150	<0.0005	<0.0005	<0.0005	<0.0005
FABRICATING PROPERTIES					
Bulk Factor		1.6–2.2	1.6–2.2	1.6–2.2	1.6–2.2
Injection Molding					
Pressure, 1000 psi		10–15	10–15	10–15	10–15
Temperature, F		330–530	330–530	330–530	330–530
Mold Shrinkage, in./in.		0.02–0.05	0.02–0.05	0.02–0.05	0.02–0.05
HEAT RESISTANCE					
Vicat Softening Point, F		250	250–260	260*	260*
CHEMICAL RESISTANCE		Same basic chemical resistance as Types I and II, but better resistance to some specific chemicals			
USES		Refrigerator parts, packaging, structural housing panels, pipe, defroster and heater ducts, sterilizable housewares and hospital equipment, hoops, battery parts, blow molded containers and parts, film wrapping materials, wire and cable insulation, and chemical resistant pipe			

* Adapted from method of Karrer, Davis and Dieterich, *Ind. & Engrg. Chem.*, Vol. 2, No. 30, '30.

Polyvinyl Chloride and Copolymers—Molded, Extruded

Type →	ASTM	Polyvinyl Chloride, Polyvinyl Chloride-Acetate: Nonrigid—General	Polyvinyl Chloride, Polyvinyl Chloride-Acetate: Nonrigid—Electrical	Polyvinyl Chloride, Polyvinyl Chloride-Acetate: Rigid—Normal Impact	Vinylidene Chloride[a]
PHYSICAL PROPERTIES					
Specific Gravity	D792	1.20–1.55	1.16–1.40	1.32–1.44	1.68–1.75
Ther Cond, Btu/hr/sq ft/°F/ft	D325	0.07–0.10	0.07–0.10	0.07–0.10	0.053
Coef of Ther Exp, 10^{-5} per °F	D696	—	—	2.8–3.3	8.78
Refractive Index	D542	—	—	—	1.60–1.63
Spec Ht, Btu/lb/°F	D570	—	—	—	0.32
Water Absorption (24 hr), %	D635	0.2–1.0	0.40–0.75	0.03–0.40	>0.1
Flammability		Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES					
Mod of Elast in Tension, 10^5 psi	D412	0.004–0.03	0.01–0.03	3.5–4.0[b]	0.7–2.0
Ten Str, 1000 psi	D412	1–3.5	2–3.2	5.5–9	4–8, 15–40
Elong (in 2 in.), %	D638	200–450	220–360	5–25	15–25, 20–30
Hardness (Rockwell)	D785	—	—	R117–120	M50–65
Hardness (Shore)	D676	A50–100	A78–100	D70–85	>A95
Impact Str (Izod notched), ft-lb/in.	D256	Variable	Variable	0.25–1.2	2–8, 0.053
Mod of Elast in Flex, psi	D790	—	—	$3.8–5.4 \times 10^5$	—
100% Modulus, psi		1300–1750	1200–2800	—	—
Flex Str, 1000 psi	D790	—	—	12.5–16	15–17, flexible
Compr Str, 1000 psi	D695	—	—	11–12	—
Compr Yld Str, 1000 psi	D695	—	—	10–11	75–85
Cold Flex Temp, F	D1043	−70 to 0	−7 to +59	—	—
Cold Bend Temp, F		−40 to −4	−49 to −4	—	—
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	$1–700 \times 10^{12}$	$4–300 \times 10^{11}$	$10^{14}–>10^{16}$	$10^{14}–10^{16}$
Dielec Str (short time), v/mil	D149	—	24–500	725–1400	—
Dielec Const (60 cycles)	D150	5.5–9.1	6.0–8.0	2.3–3.7	3–5
Dissip Factor (60 cycles)	D150	0.05–0.15	0.08–0.11	0.020–0.03	0.03–0.15
Loss Factor (60 cycles)	D150	—	1.0–1.2	0.030–0.072	—
FABRICATING PROPERTIES					
Bulk Factor		2.4–2.6	2.4–2.6	2.0–2.4	—
Compression Molding					
Pressure, 1000 psi		0.5–2	0.5–2	>1	0.5–5
Temperature, F		285–350	285–350	275–400	250–350
Injection Molding					
Pressure, 1000 psi		7–15	12–20	>20	10–30
Temperature, F		320–350	325–375	300–375	300–400
Mold Shrinkage, in./in.		0.02–0.05	0.02–0.06	0.001–0.004	0.008–0.012
Extrusion Temp, F		325–400	350–385	—	<375
HEAT RESISTANCE					
Max Rec Svc Temp, F		150–220	140–220	150–165	170–212
Heat Dist Temp, F					
66 Psi	D648	—	—	170–185	190–210
264 Psi	D648	—	—	140–170	130–150
Softening Point, F		—	—	—	240–280
CHEMICAL RESISTANCE		Generally resistant to alkalis and weak acids. Moderately to not resistant to strong acids. Not resistant to ketones and esters; aromatic hydrocarbons produce swelling			Excellent to all acids and most common alkalis[c]
USES		Parts made by molding, high speed extrusion, calendering. Blown extruded film. Vacuum cleaner parts, handlebar grips, doll parts, hair curlers, safety goggle cups, grommets, toy tires, garden hose, and protective garments	Parts made by calendering, extrusion. Insulation and jacketing for: communication and low tension power wire and cable, building wiring, appliance and machine tool cords, and switchboard cable	Parts made by calendering, laminating, molding, extrusion. Fume hoods and ducts, storage tanks, chemical piping, plating tanks, phonograph records. Sheets and shapes for decorative panels, other building uses	Extrusions: gasket rods, valve seats, flexible chemical tubing and pipe, tape for wrapping joints, chemical conveyor belts. Moldings: spray-gun handles, acid dippers, parts for rayon producing equipment

[a] Where two values or ranges are given, they represent unoriented and oriented forms, respectively.
[b] Modulus of elasticity in compression.
[c] Unaffected by aliphatic and aromatic hydrocarbons, alcohols, esters, etc.

Polyvinyl Alcohol, Butyral and Formal—Molded, Extruded

Material →		Polyvinyl Alcohol	Polyvinyl Butyral	Polyvinyl Formal
PHYSICAL PROPERTIES	ASTM			
Specific Gravity	D792	1.21–1.31	1.07–1.20	1.2–1.4
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.46	—	0.089
Coef of Ther Exp, per °F	D696	3.88–6.65 x 10^{-5}	4.4–12.7 x 10^{-5}	3.55–4.27 x 10^{-5}
Refractive Index	D542	1.49–1.53	1.48–1.49	1.5
Specific Heat, Btu/lb/°F		0.3	0.4	—
Transmittance (luminous), %		[a]	85–91	80–90
Water Absorption (24 hr), %	D570	>30	1.0–3.0	0.5–3.0
Flammability	D635	Slow burning	Slow burning	Slow burning
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	D638	—	3.5–4.0 x 10^5	5-7 x 10^5
Tensile Strength, 1000 psi	D638	1–5	4–8.5	9–11
Elongation (in 2 in.), %	D638	300–600	5–60	5–20
Hardness (Rockwell)	D785	—	L95	M85
Hardness (Shore A)		10–100	—	—
Impact Strength (Izod notched), ft-lb/in.	D256	—	0.74–1.02	0.8–20
Mod of Elast in Flex, psi		—	—	5–6 x 10^5
Flexural Strength, 1000 psi	D790	—	10	17–18
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm-cm	D257	[b]	>10^{14}	—
Dielectric Strength (short time), v/mil	D149	[b]	400	300–600
Dielectric Constant				
60 Cycles	D150	[b]	3.61	3.7
10^6 Cycles	D150	[b]	3.33	3.0
Dissipation Factor				
60 Cycles	D150	[b]	0.0070	0.010
10^6 Cycles	D150	[b]	0.0065	0.023
FABRICATING PROPERTIES				
Compression Molding				
Pressure, 1000 psi		5–15	1–2	1–10
Temperature, F		250–300	320–400	275–325
Injection Molding				
Pressure		—	11–15	14–32
Temperature, F		—	400	325–425
Mold Shrinkage, in./in.		—	—	0.0015–0.0035
HEAT RESISTANCE				
Max Rec Svc Temp, F		—	115	130–165
Heat Dist Temp, F	D648	—	115–140	155–185
CHEMICAL RESISTANCE		Good resistance to organic solvents and petroleum. Attacked by strong acids. Softened or dissolved by weak acids and by alkalis	Resistant to alkalis, aliphatic hydrocarbons, and most oils. Attacked by acids, alcohols, esters and ketones. Butyral used with wider range of solvents than Formal	
USES		Adhesives and binders, textile sizing, coating and sizing for paper, thickening agents. Molded: chemical and oxygen tubing, gaskets and diaphragms. Film: airtight bags, packaging for chemicals	Plasticized form used as interlayer for safety glass. Solution uses: adhesive primer, metal conditioner, cloth waterproofing	Base for electrical insulating enamel with high heat resistance. Metal wire and cable coatings requiring high toughness and adhesion

[a] Transparent to opaque.
[b] Under atmospheric conditions enough water will be absorbed to make most electrical measurements useless.

Acetal, Polycarbonate, Polypropylene, Chlorinated Polyether—Molded, Extruded

Material →		Acetal	Polycarbonate[a]	Polypropylene	Chlorinated Polyether
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792	1.425	1.20	0.90–0.91	1.4
Ther Cond, Btu/hr/sq ft/°F/ft		0.13	0.11	0.08	—
Coef of Ther Exp, per °F	D696	4.5×10^{-5}	3.9×10^{-5}	6.2×10^{-5}	4.4×10^{-5}
Specific Heat, Btu/lb/°F		0.35	—	0.46	—
Water Absorption (24 hr), %	D570	0.12	0.3	0.03	0.01
Flammability, ipm	D635	1.1	Self-extinguishing	—	Self-extinguishing
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	D638	—	0.33×10^{5}[b]	1.55×10^{5}	—
Tensile Strength, 1000 psi	D638	10.0	9.0–10.5	5.0	6
Elongation (total), %	D638	15	60–100	500–700	60–160
Hardness (Rockwell)	D785	M94, R120	M70, R118	R85–95	R100
Impact Strength, ft-lb/in.					
Notched	D256	1.4	12–16	1.02	0.4
Unnotched	D256	—	>60	>17	>33
Mod of Elast in Flex, psi	D790	4.1×10^{5}	3.8×10^{5}	1.7×10^{5}[c]	1.3×10^{5}
Flexural Strength, 1000 psi	D790	14.1	11–13	8.1[c]	5
Stiffness in Flex, 1000 psi	D790	—	—	114–142	—
Compressive Strength, 1000 psi	D695	5.2	11	—	—
Shear Strength, 1000 psi	D732	9.5	9.2	—	—
Yield Strength, 1000 psi	D638	—	8.0–9.0	4.3–4.9	—
Elongation (at yield), %	D638	—	5	10–20	—
ELECTRICAL PROPERTIES					
Volume Resistivity, ohm-cm	D257	$>4 \times 10^{13}$	2.1×10^{16}	$>10^{16}$	5×10^{15}
Dielectric Strength (short time), v/mil	D149	500	400	769–820	400
Dielectric Constant					
60 Cycles	D150	3.7	3.17	—	3.1
10^{6} Cycles	D150	3.7	2.96	2.0–2.1	2.8
Dissipation Factor					
60 Cycles	D150	0.004	0.0090	—	0.016
10^{6} Cycles	D150	0.004	0.0100	0.0002–0.0003	0.01
Arc Resistance, sec	D495	129	10–11	—	—
FABRICATING PROPERTIES					
Bulk Factor	D1182	—	1.74	2.25	—
Injection Molding					
Pressure, 1000 psi		15–25	15–20	Wide range	10–20
Temperature, F		380–440	550–600	Wide range	440–465
Extrusion Temp, F		—	—	340–430	360–450
Mold Shrinkage, in./in.		0.01–0.04	0.005–0.007	0.015–0.030	0.004–0.006
HEAT RESISTANCE					
Max Rec Svc Temp, F		185	—	—	—
Heat Dist Temp, F					
66 Psi	D648	338	283–293	221	300
264 Psi	D648	212	280–290	—	185
Melt Pt (crystalline), F		347	514	330	—
CHEMICAL RESISTANCE		Excellent res to most organic solvents, including aliphatic and aromatic hydrocarbons. Not rec for use with strong acids and alkalis; should be tested for use with dilute acids and weak alkalis. Affected by ultra violet light	Insoluble in aliphatic hydrocarbons, ether and alcohols; partially soluble in aromatic hydrocarbons; soluble in chlorinated hydrocarbons; slowly decomp by alkaline substances. High stability to water and to mineral and organic acids	Res to most acids, alkalis and saline solutions, even at higher temp; res to organic solvents and polar substances. Above 175 F, soluble in such aromatic substances as toluene and xylene, and such chlorinated hydrocarbons as trichloroethylene	Excellent resistance to both inorganic and organic chemicals. Resistant to all inorganic acids except fuming nitric and fuming sulfuric
USES		Appliance parts. Gears, bushings, bearings, and movie projector and typewriter parts	Gears, housings, structural parts, electronic components, telephone accessories	Structural shapes, housewares, electronic equipment, automotive parts	Valves, pump parts, pipe and sheet for high temperature corrosive environments

[a] A glass-reinforced type is now available. [b] 212 F. [c] Tinius-Olsen.

Ureas—Molded

Type[a] →		1 (alpha cellulose-filled)	2 (cellulose-filled)
PHYSICAL PROPERTIES	ASTM		
Specific Gravity	D792...	1.47–1.52	1.52
Ther Cond, Btu/hr/sq ft/°F/ft	C177...	0.17–0.244	—
Coef of Ther Exp, per °F	D696...	1.22–1.50 x 10^{-5}	—
Transmittance (luminous), %	.....	21.8	0
Water Absorption (24 hr), %	D570...	0.4–0.8	—
Flammability	D635...	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	D638...	13–16 x 10^5	—
Tensile Strength, 1000 psi	D638...	5–10	—
Elongation (in 2 in.), %	D638...	1.0	—
Hardness (Rockwell)	D785...	E94–97, M116–120	—
Impact Strength (Izod notched), ft-lb/in.	D256...	0.24–0.35	0.26–0.275
Flexural Strength, 1000 psi	D790...	10–18	10–13
Compressive Strength, 1000 psi	D695...	25–38	—
Shear Strength, 1000 psi	.....	11–12	—
ELECTRICAL PROPERTIES			
Volume Resistivity, ohm-cm	D257...	0.5–5 x 10^{11}	5–8 x 10^{10}
Dielectric Strength (short time), v/mil	D149...	300–400	340–370
Dielectric Constant			
60 Cycles	D150...	7.0–9.5	7.2–7.3
10^6 Cycles	D150...	6.4–6.9	6.4–6.5
Dissipation Factor			
60 Cycles	D150...	0.035–0.043	0.042–0.044
10^6 Cycles	D150...	0.028–0.032	0.027–0.029
Loss Factor			
60 Cycles	.....	0.24–0.38	0.30–0.32
10^6 Cycles	.....	0.18–0.22	0.17–0.19
Arc Resistance, sec	D495...	80–130	85–110
FABRICATING PROPERTIES			
Bulk Factor	.....	2.4–3.0	2.5
Compression Molding			
Pressure, 1000 psi	.....	2–8	2–5
Temperature, F	.....	275–350	275–320
Mold Shrinkage, in./in.	.....	0.006–0.014	0.007–0.008
HEAT RESISTANCE			
Heat Dist Temp, F	D648...	266–280	—
CHEMICAL RESISTANCE		High resistance to organic solvents, oils and greases. Poor resistance to acids and alkalis, depending on concentration	
USES		Such housings as radio, television, business machines, food equipment. Toilet seats, household electrical switches and plugs, buttons and cosmetic containers	Low cost items. Available only in dark color. Especially suited for electric switch plates, wiring devices and electrical parts requiring high arc resistance

[a]ASTM D705-55.

Plastics Films

Type →		Nylon 6	Polypropylene	Polyethylene		
				Type I	Type II	Type III
GENERAL PROPERTIES	ASTM					
Method of Production[a]		Extr	Extr, calndr	Extr, calndr	Extr, calndr	Extr
Forms Available		Sheets, rolls, tapes	Sheets, rolls, tapes	Sheets, rolls, tapes, tubes	Sheets, rolls, tapes	Sheets, rolls, tapes
Clarity[c]		Trp	Trp	Trp, trl, opaque	Trp, trl, opaque	Trp, trl
Min Thickness, in.		0.0005	0.00075	0.00075	0.00075	0.00075
Max Width, in.		60	60	144	60	60
Area Factor, 1000 sq in./lb/mil[d]		24	30.7	30	30	29
PHYSICAL PROPERTIES						
Specific Gravity	D792	1.12	0.90	0.92	0.935–0.938	0.940–0.945
Ten Str, 1000 psi	D882	13.8–17.0	5–10	1.6–3.0	2.5–3.5	3.5–8.0
Elong, %	D882	>200	>200	200–800	>200	50–400
Burst Str (Mullen), psi[e]	D774	—	—	48	—	—
Tear Str (Elmendorf), gm/mil	D689	50	32–1760	100–300	93–97	10–350
Fold Endurance[e]	D643	Excellent	Excellent	Good	Good	Good
Heat Sealing Range, F[f]		400–450	325–350	250–375	250–375	250–375
Water Absorp (24 hr), %	D570	1.0–1.5	0.005 Max	Negligible	Negligible	Negligible
Water Vapor Perm, gm/100 sq in./24 hr[e]	E96-53T	0.9–1.0 (1 mil)	0.06–0.10 (1 mil)	1.2–1.4 (1 mil)[o]	0.5–0.7 (1 mil)[o]	0.3–0.4 (1 mil)[o]
Gas Perm, cu cm/100 sq in./24 hr[e]						
Oxygen		6.5 (1 mil)	140 (1 mil)	550 (1 mil)	280 (1 mil)	200 (1 mil)
Nitrogen		—	—	180 (1 mil)	—	42 (1 mil)
Carbon Dioxide		—	—	2900 (1 mil)	990 (1 mil)	580 (1 mil)
CHEMICAL RESISTANCE						
Strong Acids	D543 or D1239	Poor	Excellent	Excellent[j]	Excellent[j]	Excellent[j]
Strong Alkalis		Excellent	Excellent	Excellent	Excellent	Excellent
Greases and Oils		Excellent	Very good	Fair	Fair	Fair
Solvents						
Ketone and Ester		Excellent	—	Good	Good	Good
Chlorinated		—	—	Fair	Fair	Fair
Hydrocarbon		Excellent	Very good	Fair	Fair	Fair
PERMANENCE						
Max Cont Svc Temp, F		380	300	200	230	250
Min Svc Temp, F		<−100	—	−68	<−100	<−100
Resistance to Sunlight		Fair	Fair	Fair	Fair	Fair
Dimensional Change, %		Nil	Nil	Nil	Nil	Nil
Storage Stability[k]		Excellent	Excellent	Excellent	Excellent	Excellent
Flammability (rate of burning)		Self-extinguishing	Slow	Slow	Slow	Slow

[a] Cast = casting; calndr = calendering; extr = extrusion; block = block process.
[b] ASTM D568.
[c] Trp = transparent; trl = translucent.
[d] Figures may vary with resin-plasticizer ratio.
[e] Properties particularly dependent on thickness.
[f] Unsupported film cannot be sealed on all types of heat sealers, since adhesion to metal sealer and distortion of film may be encountered.
[g] ASTM D643, Method A.
[j] Except nitric, fuming sulfuric and chlorosulfonic.
[k] Average warehouse conditions: 400–100 F, dry.
[l] Coating attacked.
[n] ASTM D643, Method B.
[o] At 95 F, 90% RH.

Plastics Films

Type →		Rigid Polyvinyl Chloride (incl copolymers)	Nonrigid Polyvinyl Chloride (incl copolymers)	Polyvinylidene Chloride (Saran)	PVC-Nitrile Rubber Blend	Polyvinyl Alcohol
GENERAL PROPERTIES	ASTM					
Method of Production[a]		Cast, calndr, extr	Cast, calndr, extr	Extr	Cast, calndr, extr	Cast
Forms Available		Sheet, rolls, tapes	Sheet, rolls, tapes, tubes	Rolls, tubes	Sheet, rolls, tapes, tubes	Rolls
Clarity[c]		Trp, trl, opaque	Trp, trl, opaque	Trp, trl, opaque	Trp, trl, opaque	Trp, trl
Min Thickness, in.		0.001	0.0005	0.0005	0.001	0.001
Max Width, in.		54	104	40	84	54
Area Factor, 1000 sq in./lb/mil[d]		19.5-22.5	20-23	16.3	22.8-23.7	21.6
PHYSICAL PROPERTIES						
Specific Gravity	D792	1.36-1.50	1.15-1.50	1.68	1.18-1.35	1.21-1.31
Ten Str, 1000 psi	D882	6.5-8.5	1-5	7-15	1.5-4.0	6-10
Elong, %	D882	5-25	50-500	25-40	250-500	400-600
Burst Str (Mullen), psi[e]	D774	—	9-20	30-70	—	185-235
Tear Str (Elmendorf), gm/mil	D689	20-150	30-1400	30	100-960	500-800
Fold Endurance[e]	D643	Poor	Good	500,000[g]	Excellent	Good
Heat Seal Temp Range, F[f]		260-400	200-400	285	220-350	300-400
Water Absorp (24 hr), %	D570	Negligible	Negligible	Negligible	Negligible	> 30
Water Vapor Perm, gm/100 sq in./24 hr[e]	E96-53T	0.5 (0.005 in.) to 2.5 (0.001 in.)	0.7 (0.005 in.) to 8.0 (0.001 in.)	0.20	7.0	> 10
Gas Perm, cu cm/100 sq in./24 hr[e]						
Oxygen		3 (0.005 in.) to 15 (0.001 in.)	50-300[m]	0.56[m]	—	—
Nitrogen		—	—	0.11[m]	—	—
Carbon Dioxide		11 (0.005 in.) to 55 (0.001 in.)	250-2000[m]	2.4[m]	—	—
CHEMICAL RESISTANCE						
Strong Acids	D543 or D1239	Excellent	Excellent	Excellent[h]	Good	Poor
Strong Alkalis		Excellent	Excellent	Good[i]	Good	Poor
Greases and Oils		Good	Fair	Excellent	Excellent	Excellent
Solvents						
Ketone and Ester		Poor	Poor	Fair	Poor	Excellent[i]
Chlorinated		Fair	Fair	Fair	Fair	Excellent
Hydrocarbon		Excellent	Good	Excellent	Good	Excellent
PERMANENCE						
Max Cont Svc Temp, F		200-220	150-180	290	200	—
Min Svc Temp, F		-70	-50	Good	-40	—
Resistance to Sunlight		Good	Good	Excellent	Fair	Excellent
Dimensional Change, %		Nil	Nil	Nil	Nil	High
Storage Stability[k]		Excellent	Excellent	Excellent	Excellent	Excellent
Flammability (rate of burning)		Self-extinguishing	Slow to self-extinguishing	Self-extinguishing	Slow to self-extinguishing	Slow

[a] Cast = casting; calndr = calendering; extr = extrusion; block = block process.
[c] Trp = transparent; trl = translucent.
[d] Figures may vary with resin-plasticizer ratio.
[e] Properties particularly dependent on thickness.
[f] Unsupported film cannot be sealed on all types of heat sealers, since adhesion to metal sealer and distortion of film may be encountered.
[g] ASTM D643, Method A.
[h] Except sulfuric and nitric.
[i] Except ammonium hydroxide.
[k] Average warehouse condition: 40-100 F, dry
[m] 0.001-in. film.

continued on next page

Plastics Films

Type →	ASTM	Polytetrafluoroethylene	Polytrifluoromonochloroethylene	Polystyrene (oriented)	Polyester (polyethylene terephthalate)	Rubber Hydrochloride	Ethyl Cellulose
GENERAL PROPERTIES							
Method of Production[a]		Block	Extr	Extr	Extr	Cast	Cast, block, extr
Forms Available		Sheet, tapes	Sheet, tubes	Sheet, rolls	Sheet, rolls	Sheet, rolls, tapes	Sheet, rolls, tapes
Clarity[c]		Trp	Trp, trl	Trp, trl, opaque	Trp, opaque	Trp, trl, opaque	Trp
Min Thickness, in.		0.002	0.002	0.001	0.00025	0.0004	0.003
Max Width, in.		12	20	40	55	60	30
Area Factor, 1000 sq in./lb/mil[d]		13	12	26.1	20	24	24
PHYSICAL PROPERTIES							
Specific Gravity	D792	2.15	2.11	1.05-1.07	1.39	1.12-1.15	1.14-1.16
Ten Str, 1000 psi	D882	2-3	6.3-6.6	7-12	17-28	5-6	6-10
Elong, %	D882	200-250	90-200	3-10	70-130[m]	350-500	20-35
Burst Str (Mullen), psi[e]	D774	—	42	30-60	45[m]	—	30-86
Tear Str (Elmendorf), gm/mil	D689	—	200-350	2-8	18	1000-1500	2-15
Fold Endurance[e]	D643	—	—	—	Excellent	10^4-10^6	2700
Heat Seal Range, F[f]		Not heat sealable	415-450	220-300	490	225-350	—
Water Absorp (24 hr), %	D570	None	None	0.04-0.06	Negligible	Negligible	Low
Water Vapor Perm, gm/100 sq in./24 hr[e]	E96-53T	—	0.00	6.2	1.8[m]	0.5-15.5	10-50
Gas Perm, cu cm/100 sq in./24 hr[e]							
Oxygen		—	0.76[m]	213	5.7[m]	2-405	—
Nitrogen		—	5.5[m]	42	0.9[m]	—	—
Carbon Dioxide		—	8.0[m]	926	17.5[m]	36-2616	—
CHEMICAL RESISTANCE							
Strong Acids	D543 or D1239	Excellent	Excellent	Good	Excellent	Good	Poor
Strong Alkalis		Excellent	Excellent	Excellent	Excellent	Good	Excellent
Greases and Oils		Excellent	Excellent	Good	Excellent	Excellent	Good
Solvents							
Ketone and Ester		Excellent	Excellent	Poor	Excellent	Fair	Poor
Chlorinated		Excellent	Excellent	Good	Excellent	Fair	Poor
Hydrocarbon		Excellent	Excellent	Good	Excellent	Excellent	Fair
PERMANENCE							
Max Cont Svc Temp, F		565-585	300-395	160-180	490	205	210-275
Min Svc Temp, F		-90	-120	Good	-80	-20	-75
Resistance to Sunlight		Excellent	Excellent	Fair	Fair	Fair	Good
Dimensional Change, %		Nil	Nil	Nil	Nil	Slight	Slight
Storage Stability[k]		Excellent	Excellent	Good	Excellent	Good	Excellent
Flammability (rate of burning)		Nil	Nil	Slow	Self-extinguishing	Self-extinguishing	Slow

[a]Cast = casting; calndr = calendering; extr = extrusion; block = block process.
[c]Trp = transparent; trl = translucent.
[d]Figures may vary with resin-plasticizer ratio.
[e]Properties particularly dependent on thickness.
[f]Unsupported film cannot be sealed on all types of heat sealers, since adhesion to metal sealer and distortion of film may be encountered.
[k]Average warehouse conditions: 40-100 F, dry.
[m]0.001-in. film.

Plastics Films

Type →		Cellophane		Cellulose			
		Plain	Coated	Acetate[m]	Triacetate (42.5-44% acetyl)	Acetate Butyrate[m]	Nitrate
GENERAL PROPERTIES	ASTM						
Method of Production[a]		Extr	Extr	Extr, cast	Cast	Extr, cast	Cast, block
Forms Available		Sheet, rolls, tapes	Sheet, rolls	Sheet, rolls, tapes, tubes	Sheet, rolls	Sheet, rolls	Sheet, rolls
Clarity[c]		Trp	Trp	Trp, trl, opaque	Trp	Trp, opaque	Trp, trl, opaque
Min Thickness, in.		0.0009	0.0009	0.0005	0.003	0.0009	0.0005
Max Width, in.		60	60	60	45	40	50
Area Factor, 1000 sq in./lb/mil[d]		21.5	19.5	22	21.7	23.3	20
PHYSICAL PROPERTIES							
Specific Gravity	D792	1.45	1.40-1.55	1.25-1.35	1.28	1.16-1.18	1.42-1.46
Ten Str, 1000 psi	D882	8-19	7-16	9-14	9-11	6-9	10-11
Elong, %	D882	15-25	15-50	15-35	25-35	50-70	30-40
Burst Str (Mullen), psi[e]	D774	—	—	30-80	100-150	40-75	40-50
Tear Str (Elmendorf), gm/mil	D689	2-10	2-15	2-15	10-15	4-16	—
Fold Endurance[e]	D643	7000-22,000	—	1500-2000[n]	200-300[n]	900-1300[n]	50-250[n]
Heat Sealing Range, F[f]		Not heat sealable	200-350	400-500	—	—	—
Water Absorp (24 hr), %	D570	High	High	Low	Low	Low	Low
Water Vapor Perm, gm/100 sq in./24 hr[e]	E96-53T	High	0.2-1.0	10-40	10	60	—
Gas Perm, cu cm/100 sq in./24 hr[e]							
Oxygen		—	Low	3-6[m]	—	—	—
Nitrogen		—	Low	—	—	—	—
Carbon Dioxide		—	Low	12-31[m]	—	—	—
CHEMICAL RESISTANCE							
Strong Acids	D543 or D1239	Poor	Poor	Poor	Poor	Poor	Good
Strong Alkalis		Poor	Poor	Poor	Poor	Poor	Fair
Greases and Oils		Excellent	Good[l]	Good	Good	Fair	Fair
Solvents							
Ketone and Ester		Excellent	Poor[l]	Poor	Poor	Poor	Poor
Chlorinated		Excellent	Excellent	Poor	Poor	Poor	Fair
Hydrocarbon		Excellent	Fair	Good	Good	Good	Fair
PERMANENCE							
Max Cont Svc Temp, F		375	300-375	250-300	300-400	200-250	140
Min Svc Temp, F		0	0	-25	-25	-25	—
Resistance to Sunlight		Good	Good	Good	Good	Good	Poor
Dimensional Change, %		3-5	2-5	0.2-0.8	0.4	0.3	Nil
Storage Stability[k]		Good	Good	Excellent	Excellent	Excellent	Fair
Flammability (rate of burning)		Fast	Fast	Slow, 70-100[b]	Self-extinguishing	Slow, 50-80[b]	Fast

[a] Cast = casting; calndr = calendering; extr = extrusion; block = block process.
[b] ASTM D 568.
[c] Trp = transparent; trl = translucent.
[d] Figures may vary with resin-plasticizer ratio.
[e] Properties particularly dependent on thickness.
[f] Unsupported film cannot be sealed on all types of heat sealers, since adhesion to metal sealer and distortion of film may be encountered.
[g] ASTM D 643, Method A.
[k] Average warehouse conditions: 40-100 F, dry.
[l] Coating attacked.
[m] 0.001-in. film
[n] ASTM D 643, Method B.

High Pressure Laminates (General Purpose)—Sheet, Rod, Tube

Grade →	CE (canvas-phenolic)	A (asbestos paper-phenolic)	AA (asbestos cloth-phenolic)	G-3 (glass cloth-phenolic)
PHYSICAL PROPERTIES				
Density, gm/cu cm	1.32	1.72	1.70	1.65
Ther Cond, Btu/sq ft/hr/°F/ft	0.17	—	—	—
Max Rec Svc Temp, F				
Short Time	300	400	400	410
Continuous	250	275	275	290
Coef of Ther Exp, 10^{-5} per °F				
Lengthwise	1.04	0.55	1.04	0.83
Crosswise	1.22	0.89	1.04	1.04
Water Absorption (24 hr), %				
1/16 In. Thick	1.3	1.3	2.5	1.8
1/8 In. Thick	0.9	0.8	2.0	1.2
1/2 In. Thick	0.5	0.5	1.2	0.7
MECHANICAL PROPERTIES				
Ten Str, 1000 psi				
Lengthwise	11	10	12	23
Crosswise	9	8	10	20
Flex Str, 1000 psi				
Lengthwise	22	20	21	32
Crosswise	17	18	19	28
Compr Str (flatwise), 1000 psi	39	40	38	50
Mod of Elast in Flex, 10^5 psi				
Lengthwise	9	23	16	15
Crosswise	8	14	14	12
Impact Str (edgewise), ft-lb/in.				
Lengthwise	1.6	1.0	4.5	7.5
Crosswise	1.4	0.9	4.0	6.0
Hardness (Rockwell)	M105	M111	M103	M120
Bond Strength, psi	2200	800	2000	1000
ELECTRICAL PROPERTIES				
Dielec Str (perp, short time), v/mil				
1/16 In. Thick	500	225	85	700
1/8 In. Thick	360	160	70	600
Dielec Str (par., step by step, 1/8 in. thick), kv				
Cond A	45	10	—	—
Cond D48/50	5	—	—	—
Dissip Factor (10^6 cycles)				
Cond A	0.055	—	—	0.030
Cond D24/23	0.070	—	—	—
Dielec Const (10^6 cycles, cond A)	5.3	—	—	6.5
Insulation Res (cond 35/90), megohms	—	—	—	200
Arc Resistance, sec	10	10	10	10
AIEE Insulation Class	A	B	B	B
USES	Switchboard panels, circuit breaker and switch arms, terminal blocks, electrode supports for plating tanks, bases for motors, bobbin heads (often in combination with XX)	Mechanical parts in drying ovens, tenter rails	Rotor vanes, water pumping thrust washers, armature slot wedges, caustic resistant applications, electric appliance insulation	Armature slot wedges, structural parts requiring good electrical properties, electrical equipment operating at relatively high temperatures

High Pressure Laminates (General Purpose)—Sheet, Rod, Tube

Grade →	G-5 (glass cloth–melamine)	G-10 (glass cloth–epoxy)	GPO-1 (glass mat–polyester)	Commercial and Trunk Fibre
PHYSICAL PROPERTIES				
Density, gm/cu cm	1.9	1.78	1.5–1.9	1.15
Ther Cond, Btu/sq ft/hr/°F/ft	0.29	—	—	—
Max Rec Svc Temp, F				
Short Time	425	350	350	—
Continuous	300	250	250	—
Coef of Ther Exp, 10^{-5} per °F				
Lengthwise	0.55	—	1.1	1.1
Crosswise	0.61	—	—	1.7
Water Absorption (24 hr), %				
1/16 In. Thick	1.0	0.09	1.0	66
1/8 In. Thick	0.6	0.06	0.70	61
1/2 In. Thick	0.4	0.03	0.35	36
MECHANICAL PROPERTIES				
Ten Str, 1000 psi				
Lengthwise	37	—	12	16
Crosswise	30	—	10	9
Flex Str, 1000 psi				
Lengthwise	65	72	23	18
Crosswise	50	63	20	15
Compr Str (flatwise), 1000 psi	70	—	40	30
Mod of Elast in Flex, 10^5 psi				
Lengthwise	17	—	15	—
Crosswise	15	—	13	—
Impact Str (edgewise), ft-lb/in.				
Lengthwise	12.0	14.4	12	2.3
Crosswise	9.0	10.6	10	2.1
Hardness (Rockwell)	M120	—	M93	R80
Bond Strength, psi	1700	2500	1000	—
ELECTRICAL PROPERTIES				
Dielec Str (perp, short time), v/mil				
1/16 In. Thick	600	810	650	200
1/8 In. Thick	500	570	500	195
Dielec Str (par., step by step, 1/8 in. thick), kv				
Cond A	32	55	60	—
Cond D48/50	12	60	33	—
Dissip Factor (10^6 cycles)				
Cond A	0.016	0.0119	0.03	—
Cond D24/24	0.030	0.0126	0.08	—
Dielec Const (10^6 cycles, cond A)	6.8	4.8	4.3	—
Insulation Res (cond C96/35/90), megohms	100	1×10^5	—	—
Arc Resistance, sec	200	100	140	80
AIEE Insulation Class	B	B	B	A
USES	Switchboard panels, arc barriers and circuit breaker parts, armature and slot wedges, structural parts, electrical applications requiring high strength and arc resistance, high temperature applications	Printed circuits; other applications where high insulation resistance and dimensional stability, are required.	Panel boards, slot wedges, spacers, coil blocking, layer insulation, core corner protectors, terminal plates, structural applications	Washers, terminal block covers, insulating plates and switch covers, arch supporters, bobbin and coil spool heads, arc barriers, shoe fiber, switch and appliance insulation, knee pads, golf club head plates, deep formed parts, trunks, cases, wastebaskets, mill boxes

High Pressure Laminates (Mechanical)—Sheet, Rod, Tube

Grade →	X (kraft paper-phenolic)	P (paper-plasticized phenolic)	PC (paper-phenolic)	ES 1, 2, 3 (paper base)[a]
PHYSICAL PROPERTIES				
Density, gm/cu cm	1.35	1.33	1.34	—
Ther Cond, Btu/hr/sq ft/°F/ft	0.17	0.17	0.17	—
Max Rec Svc Temp, F				
Short Time	275	275	250	—
Continuous	225	250	200	—
Coef of Ther Exp, 10^{-5} per °F				
Lengthwise	1.1	0.77	—	—
Crosswise	1.39	1.22	—	—
Water Absorption (24 hr), %				
1/16 In. Thick	4.0	2.2	3.2	2.5
1/8 In. Thick	2.3	1.5	2.0	1.8
1/2 In. Thick	0.9	—	—	—
MECHANICAL PROPERTIES				
Ten Str, 1000 psi				
Lengthwise	20	12	10.5	12-15
Crosswise	16	9	8.5	8-12
Flex Str, 1000 psi				
Lengthwise	28	15	14	15
Crosswise	23	13	11	15
Compr Str (flatwise), 1000 psi	36	25	22	—
Mod of Elast in Flex, 10^5 psi				
Lengthwise	18	12	10	—
Crosswise	13	9	8	—
Impact Str (edgewise), ft-lb/in.				
Lengthwise	0.9	0.8	0.9	0.25
Crosswise	0.7	0.6	0.8	0.22
Hardness (Rockwell)	M110	M90	M70	M118
Bond Strength, psi	900	—	—	—
ELECTRICAL PROPERTIES				
Dielec Str (perp, short time), v/mil				
1/16 In. Thick	700	650	600	—
1/8 In. Thick	500	470	425	—
Dielec Str (par., step by step, 1/8 in. thick), kv				
Cond A	—	50	—	—
Cond D48/50	—	10	—	—
Dissip Factor (10^6 cycles)				
Cond A	—	—	—	—
Cond D24/23	—	—	—	—
Dielec Const (10^6 cycles, cond A)	—	—	—	—
Insulation Res (cond C96/35/90), megohms	—	—	—	—
Arc Resistance, sec	10	—	—	—
AIEE Insulation Class	A	A	A	A
USES	Structural parts for radio, aircraft and electrical equipment and switchgear. Terminal boards or panels, insulating washers, bushings, coil forms, brush-holder bushings	Insulating washers, terminal boards, plug and socket bases, switch bases and panels for subassemblies	Motor and generator terminal boards, insulating washers, terminal strips, switch bases and panels, staked terminal boards and strips	Engraved nameplates, signs

[a]ES-1 is melamine laminate; ES-2 is phenolic laminate; ES-3 has phenolic core, melamine base.

High Pressure Laminates (Mechanical)—Sheet, Rod, Tube

Grade →	C (cotton canvas-phenolic)	L (cotton linen-phenolic)	MC (cotton fabric-melamine)	Bone Fibre
PHYSICAL PROPERTIES				
Density, gm/cu cm	1.35	1.34	1.5	1.3
Ther Cond, Btu/hr/sq ft/°F/ft	0.17	0.17	0.17	0.17
Max Rec Svc Temp, F				
Short Time	275	275	275	—
Continuous	225	225	225	—
Coef of Ther Exp, 10^{-5} per °F				
Lengthwise	1.04	0.77	—	1.1
Crosswise	1.22	1.04	—	1.7
Water Absorption (24 hr), %				
1/16 In. Thick	4.4	1.3	2.2	55
1/8 In. Thick	1.6	0.4	1.6	48
1/2 In. Thick	1.0	0.5	1.0	25
MECHANICAL PROPERTIES				
Ten Str, 1000 psi				
Lengthwise	11	14	11	17
Crosswise	9	10	7	10
Flex Str, 1000 psi				
Lengthwise	22	23	23	21
Crosswise	18	18	18	17
Compr Str (flatwise), 1000 psi	37	35	45	36
Mod of Elast in Flex, 10^5 psi				
Lengthwise	10	11	—	10
Crosswise	9	8	—	7
Impact Str (edgewise), ft-lb/in.				
Lengthwise	2.3	1.3	0.9	2.3
Crosswise	2.2	1.2	0.9	2.1
Hardness (Rockwell)	M103	M105	M115	R100
Bond Strength, psi	2000	1700	1900	—
ELECTRICAL PROPERTIES				
Dielec Str (perp, short time), v/mil				
1/16 In. Thick	500	500	—	200
1/8 In. Thick	360	360	—	200
Dielec Str (par., step by step, 1/8 in. thick) kv				
Cond A	15	15	—	—
Cond D48/50	—	—	—	—
Dissip Factor (10^6 cycles)				
Cond A	—	0.055	—	—
Cond D24/23	—	0.070	—	—
Dielec Const (10^6 cycles, cond A)	6.0	5.8	—	—
Insulation Res (cond C96/35/90), megohms	—	—	—	—
Arc Resistance, sec	10	10	100	100
AIEE Insulation Class	A	A	—	A
USES	Gears and pinions, cams, pulleys, bobbin heads, chemical piping and fittings, bearings	Small gears and pinions, parts requiring intricate machining, breaker arms, fairleads and knobs	Plating barrel applications; others requiring good resistance to caustics	Gears, cams, fairleads, bushings, grommets, switch handles, terminal blocks, armature slot wedges, threaded and tapped pieces

High Pressure Laminates (Electrical)—Sheet, Rod, Tube

Grade →	XX (paper-phenolic)	XXP (paper-phenolic)	XXX (paper-phenolic)	XXXP (paper-plasticized phenolic)	LE (cotton linen-phenolic)
PHYSICAL PROPERTIES					
Density, gm/cu cm	1.34	1.32	1.32	1.29	1.32
Ther Cond, Btu/hr/sq ft/°F/ft	0.17	0.17	0.17	0.17	0.17
Max Rec Svc Temp, F					
Short Time	300	275	300	275	300
Continuous	250	250	250	250	250
Coef of Ther Exp, 10^{-5} per °F					
Lengthwise	0.94	1.05	0.94	1.04	1.04
Crosswise	1.33	1.66	1.28	1.66	1.44
Water Absorption (24 hr), %					
1/16 In. Thick	1.3	1.3	0.8	0.40	1.3
1/8 In. Thick	0.9	0.9	0.5	—	0.8
1/2 In. Thick	0.5	—	0.3	—	0.5
MECHANICAL PROPERTIES					
Ten Str, 1000 psi					
Lengthwise	16	11	15	12	13.5
Crosswise	13	8.5	12	9.5	9.5
Flex Str, 1000 psi					
Lengthwise	18	18	18	21	18
Crosswise	14	14	14	15	15
Compr Str (flatwise), 1000 psi	34	25	32	25	37
Mod of Elast in Flex, 10^5 psi					
Lengthwise	14	9	13	11	10
Crosswise	11	7	10	8	8
Impact Str (edgewise), ft-lb/in.					
Lengthwise	0.55	0.55	0.5	0.5	1.3
Crosswise	0.50	0.50	0.45	0.4	1.2
Hardness (Rockwell)	M105	M100	M110	M110	M105
Bond Strength, psi	1100	—	1200	—	1800
ELECTRICAL PROPERTIES					
Dielec Str (perp, short time), v/mil					
1/16 In. Thick	700	700	650	1000	500
1/8 In. Thick	500	500	470	700	360
Dielec Str (par., step by step, 1/8 in. thick), kv					
Cond A	50	65	65	65	50
Cond D48/50	10	15	15	33	6
Dissip Factor (10^6 cycles)					
Cond A	0.040	0.037	0.034	0.027	0.048
Cond D24/23	0.046	0.045	0.038	0.030	0.058
Dielec Const (10^6 cycles, cond A)	5.3	4.5	4.7	4.27	5.3
Insulation Res (cond C96/35/90), megohms	60	500	1000	20,000	30
Arc Resistance, sec	10	10	10	10	10
AIEE Insulation Class	A	A	A	A	A
USES	Panels for switchboards and instruments, switch and circuit breaker arms, terminal blocks for motors and transformers, coil forms for radio and television, brush holder bushings, bobbin heads and spools	Condenser stator brackets, wave change switch rotors and stators, plug and socket bases, terminal boards and subpanels, insulating washers	Panels for radio and television equipment; jack spacers, radio coil forms, high voltage switchgear	Condenser stator brackets, wavechange switch rotors and stators, terminal boards and subpanels, coil support bases	Terminal blocks and strips, panels, high humidity applications

High Pressure Laminates (Electrical)—Sheet, Rod, Tube

Grade →	G-2 (glass cloth–phenolic)	G-6 (glass cloth–silicone)	G-7 (glass cloth–silicone)	N-1 (nylon fabric–phenolic)	Electrical Insulation Fibre
PHYSICAL PROPERTIES					
Density, gm/cu cm	—	1.65	1.68	1.15	1.20
Ther Cond, Btu/hr/sq ft/°F/ft	—	0.17	0.17	—	—
Max Rec Svc Temp, F					
Short Time	410	500	500	200	—
Continuous	290	400	400	165	—
Coef of Ther Exp, 10^{-5} per °F					
Lengthwise	—	0.56	—	—	1.1
Crosswise	—	0.55	—	—	1.7
Water Absorption (24 hr), %					
1/16 In. Thick	1.50	0.3	0.3	0.3	66
1/8 In. Thick	0.95	0.25	0.20	0.2	61
1/2 In. Thick	0.55	0.15	0.15	0.1	36
MECHANICAL PROPERTIES					
Ten Str, 1000 psi					
Lengthwise	16	13	23	8.5	21
Crosswise	11	10	18	8	10
Flex Str, 1000 psi					
Lengthwise	30	23	44	18	20.5
Crosswise	20	19	37	15	14.5
Compr Str (flatwise), 1000 psi	38	40	45	—	34
Mod of Elast in Flex, 10^5 psi					
Lengthwise	13	—	14	6	—
Crosswise	10	—	12	5	—
Impact Str (edgewise), ft-lb/in.					
Lengthwise	6.6	15.1	12.1	3.7	3
Crosswise	4.7	9.5	9.6	3.3	2.9
Hardness (Rockwell)	M110	M95	M100	M105	R70
Bond Strength, psi	1400	1000	800	1200	—
ELECTRICAL PROPERTIES					
Dielec Str (perp, short time), v/mil					
1/16 In. Thick	500	250	400	600	215
1/8 In. Thick	425	185	350	450	200
Dielec Str (par., step by step, 1/8 in. thick), kv					
Cond A	30	50	55	62	—
Cond B48/50	10	45	30	55	—
Dissip Factor (10^6 cycles)					
Cond A	0.025	0.0022	0.0015	0.024	—
Cond D24/23	0.080	0.0227	0.0150	0.030	—
Dielec Const (10^6 cycles, cond A)	5.5	4.18	3.9	3.3	—
Insulation Res (cond C96/35/90), megohms	5000	4000	2500	5×10^4	—
Arc Resistance, sec	—	220	220	—	125
AIEE Insulation Class	B	H	H	A	A
USES	Class B insulation; other applications where good temperature resistance is required but mechanical properties are not critical	Insulation applications where high temperature resistance, arc resistance and low losses are needed, such as Class H transformers	Radio transmitter parts; Class H transformers; low loss, high frequency radio and radar insulators; motor slot wedges; slot liners; top sticks	High voltage applications; radio wave change switch stators and rotors, where low losses are critical; electrical insulating parts that must be postformed	Armature slot insulation, armature end laminations; field coil insulation, metal box liners, washers, arc shields, formed slot wedges, gaskets, specialties

Glass-Reinforced Plastics (Low Pressure)—Molded Laminates [a]

Type →		Polyester (rigid styrene type)		Silicone–Woven Fabric	Epoxy–Woven Fabric
		Mat	Woven Fabric		
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792	1.15–2.2	1.6–2.0	1.6–1.93	1.6–1.85
Coef of Ther Exp, 10^{-5} per °F	D325	1.0–1.4	—	—	—
Water Absorption (24 hr), %	D570	0.1–2.0	0.1–0.8	0.03–0.1	0.04–0.08
Flammability (<0.050 in.), sq in./min.	D635	2.0 to self-exting	1.0 to self-exting	0–120 [c]	—
MECHANICAL PROPERTIES					
Ten Str, 1000 psi	D638	8–25	25–55	20–40.6 [d]	40–85
Hardness					
Rockwell	D785	M80–120	M100–120	—	M100–112
Barcol		40–55	55–65	50–75	62–66
Impact Str (Izod), ft-lb/in. notch	D256	7–15	13–18	—	12–18
Mod of Elast in Flex, 10^6 psi	D790	10–25	20–38	18–32 [d]	30–46
Flex Str, 1000 psi	D790	20–40	40–75	23–47 [d]	65–120
Compr Str, 1000 psi	D695	15–35	25–45	9.3–24 [d]	45–52
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	10^{11}	10^{11}	2.4–14 x 10^{14}	10^{16}
Dielec Str (short time, ⅛ in.), v/mil	D149	300–800	350–700	100–388	450–550
Dielec Const					
60 Cycles	D150	3.4–6.0	4.1–6.0	—	—
1000 Cycles	D150	3.4–5.8	4.0–5.8	—	—
10^6 Cycles	D150	3.4–5.6	3.8–5.6	3.5–3.97	4.2–4.9
Dissip Factor (10^6 cps)	D150	0.01–0.03	0.01–0.03	0.001–0.003	—
Loss Factor					
60 Cycles	D150	0.1–0.3	0.08–0.3	—	—
1000 Cycles	D150	0.07–0.3	0.06–0.3	—	—
10^6 Cycles	D150	0.03–0.2	0.03–0.2	—	0.05–0.09
Arc Resistance, sec	D495	90–130	90–180	225–250	130–185
HEAT RESISTANCE					
Max Rec Svc Temp, F		250–400	250–400 [b]	450–500	250–400
Heat Dist Temp (264 psi), F	D648	200–550	390–550	—	—
CHEMICAL RESISTANCE		Slightly to heavily attacked by strong acids. Attacked by strong alkalis, ketones and chlorinated solvents		Satisfactory resistance to aviation gas, lube oils, 40% sulfuric acid, 5% hydrochloric acid, and Freon 114. Slightly attacked by 5% hydrochloric acid Severely attacked by acetone, methyl ethyl ketone, ethyl alcohol, isopropyl ether, toluene, cellosolve, carbon tetrachloride, ethylene dichloride and trichlorethylene	Excellent resistance to organic liquids, such as alcohols and hydrocarbons. Resistant to weak acids and some strong acids. Slightly affected by some strong alkalis. Relatively poor general resistance to acetone, glacial acetic acid, 30% nitric acid and 30% peroxide
USES		Either mat, cloth or combination of both used, depending on strength and economic requirements. Represents largest volume of all low pressure reinforced plastics. Used for boats, car bodies and parts, aircraft parts, chairs, trays, skis, tote boxes, laundry tubs, machine housings, chemical storage tanks, architectural building panels		Special high temperature structural or electrical parts, such as aircraft radomes and ductwork, thermal and arc barriers, covers and cases for high frequency equipment	High strength parts, such as laminated tools for metal forming, aircraft structural parts, pipe, leaf or coil springs, high strength electrical or chemical resistant parts

[a] Range of values is intended only to indicate general order of magnitude. Specific properties vary widely with type and quantity of reinforcement resin formulation and fabricating practice.
[b] A TAC-polyester is now available for continuous use at 500 F.
[c] When tested according to method 2023 of Spec. MIL L–P–406.
[d] A primary attribute of silicones is good strength retention after continuous exposure to 450–500 F.

Plastics and Rubber Foams—Flexible

NATURAL RUBBER (LATEX)

Density, lb/cu ft	6.0–7.0
Ther Cond, Btu/hr/sq ft/°F/ft	0.021–0.025
Tensile Strength, psi	10–20
Max Rec Svc Temp, F	160
Flammability	Burns
Tear Strength, lb/in.	1.2
Resilience, %	64
Rebound, in.	2.5
Elongation, %	380
Compression Loss, %	
50,000 Flexes	13.0
300,000 Flexes	15.0
Compression Set, %	
22 Hr at 158 F	4.6
22 Hr at 177 F	4.1
Hysteresis Loss, %	23.2
RMA Compression, lb	30.0

POLYETHYLENE (CELLULAR)[a]

Tensile Strength	670
Elongation, %	310
Specific Gravity	0.47
Dielectric Strength, v/mil	
Short Time	220
Long Time	190
Dissipation Factor	
1000 Cycles	0.00033
10,000 Cycles	0.00038
Dielectric Constant	
1000 Cycles	1.48
10,000 Cycles	1.49

[a]Wire insulation for No. 14 AWG (0.250-in. o. d.). Wire insulation is the primary use of cellular polyethylene at present.

VINYL (OPEN CELL)

Density, lb/cu ft	4 and up
Heat Sealability	Excellent
Tensile Strength, psi	10–200
Elongation, %	75–300
Flammability	Self-extinguishing
Indentation Load	
Deflection (25% def)	
Original, lb/50 sq in.	3–500
After Aging, % chg[a]	±20
Compression Set (max, 2 hr at 158 F), %	15
Set after Dynamic Flexing (max, 250,000 cycles), %	10
Chemical Resistance[b]	
Strong Acids	E
Strong Alkalis	E
Grease, Oils	G
Organic Solvents	P to E
Water	E
High Humidity	E
Sunlight	G

[a]Air oven aging 22 hr, 212 F.
[b]E = excellent; G = good; P = poor.

SYNTHETIC RUBBERS

Type →	Neoprene	Butadiene-Styrene (GR-S)	Butadiene-Acrylonitrile
Density, lb/cu ft	10–30	4.5	10–25
Ther Cond, Btu/hr/sq ft/°F/ft	0.021–0.029	0.018	0.021–0.025
Tensile Strength, psi	20–100	80	40
Max Rec Svc Temp, F	180	160	210

URETHANES

Density[a] →	1	2-4	6-8	10-12	16-20
Yld Str (0.2% offset), psi	2.5	4–20	50–75	200	—
Compr Str (50% defl), psi	5	9–48	78–150	200–380	—
Coef of Ther Exp (−22 to 86 F) 10^{-5} per °F	—	1.4	—	—	5
Ther Insulation Coef (K)	0.20	0.20–0.21	0.22–0.23	0.26	0.28–0.30
Water Absorption, lb/cu ft					
25-Day Soak	28	22.8–24	—	—	2–4
120 Hr at 50% RH	0.005	0.006–0.027	—	—	0.067–0.084
120 Hr at 98% RH	0.38	0.38–0.39	—	—	0.359–0.560
Dielec Const (1000 cycles)	—	2.2–2.3	—	2.5	2.70–2.85
Vol Res, 10^{14} ohm-cm	—	6.8–6.9	—	7.2	7.7–8.3
Sound Absorption Coef					
250 Cycles	—	0.73	0.20	0.22	—
500 Cycles	—	0.33	0.22	0.21	—
1000 Cycles	—	0.37	0.20	0.31	—
Bond Str, psi					
Aluminum	6	10–27	—	56	158
Glass	5	9–25	—	50	142
Steel	7	12–29	—	62	146
Wood	8	17–29	—	62	170
Flame Res[b]					
2 Lb/Cu Ft	Incombustible				
10 Lb/Cu Ft	Self-extinguishing				
Max Rec Svc Temp, F	200				
Heat Dist Temp (5 psi flex, 0.10 in. defl), F	130				
Chemical Res	Swell slightly in many chemical solutions. Attacked by strong acids and alkalis				

[a]Density in lb per cu ft.
[b]Federal Bldg Spec SSA118A.

Plastics Foams—Rigid

SILICONES

Density[a] →	12[b]	14[b]	16[c]
Compr Str (orig), psi	100	200	325
Compr Str (after aging), psi[d]			
77 F, 200 Hr	100	190	210
500 F, 1/2 Hr	5	25	70
500 F, 200 Hr	20	45	80
Weight Loss During Expansion, %	1.2	1.3	1.0
Weight Loss After Heating, %			
1000 Hr, 500 F	3.5	2.6	2.6
1000 Hr, 570 F	8.0	4.2	4.2
72 Hr, 700 F	8.5	5.2	5.2
Water Abs (24 hr), %	3.2	2.3	2.1
Heat Dist Temp, F	>700	>700	>700
Flammability	No burn	No burn	No burn
Dielec Const (10^6 cycles)	1.23	1.25	1.26
Dissip Factor (10^6 cycles)	0.0004	0.00102	0.00105
Ther Cond, Btu/hr/sq ft/°F/ft	0.025	0.025	0.025

[a] Density in lb per cu ft.
[b] Expanded at 320 F.
[c] Prefoamed; expanded at 320 F. Heat aged at 500 F.

POLYSTYRENES AND CELLULOSE ACETATE

Type, Density[a] →	Polystyrenes				Cellulose Acetate (prefoamed)
	Prefoamed		Foam-in-Place		
	1.3-2.0	3.0-4.2	2-4	6-10	4-8
Compr Yld Str, psi	10–35	50–140	15–50[d]	60–100[d]	128–235
Ten Str, psi	30–100	105–185	30–85	90–130	112–183
Shear Str, psi	15–45	55–95	—	—	100–185
Flex Str, psi	>32	<170	40–120	130–310	73–177
Compr Mod of Elast, 1000 psi	0.45–1.75	1.7–5.3	—	—	5.5–13.5
Flex Mod of Elast, 1000 psi	0.20–1.9	—	—	—	3.5–5.5
Impact Str (Izod), ft-lb/in. notch	0.5–2.7	—	2.0–3.0[e]	3.0–5.5[e]	0.01–1.15
Flammability, ipm	Available self-ext		—	—	4.2–8.5
Ther Cond, Btu/hr/sq ft/°F/ft	0.020–0.024		0.018–0.019	0.020–0.023	0.025–0.027
Coef of Ther Exp, per °F	2.5×10^{-6}		—	—	$2.0–2.5 \times 10^{-6}$
Spec Ht, Btu/lb/°F	0.27		—	—	—
Max Rec Svc Temp, F	155–175		185	185	200–350
Water Absorption (vol), %	<6		—	—	0.15, 1.05[b]
Water Vapor Transmission[c]	1.5–3.0		—	—	—
Dielec Const	<1.07		1.19[f]	—	1.10–1.12
Dissip Factor	<0.004		>0.0005[g]	—	0.002–0.003

[a] Density in lb per cu ft.
[b] Absorption in lb per cu ft at 50 and 100% RH, respectively.
[c] Grains/sq ft/hr/in. Hg.
[d] At 5% offset.
[e] Unnotched, in.-lb/in.
[f] At 4–6 lb/cu ft density.
[g] At 2–10 lb/cu ft density.

EPOXIES, PHENOLICS AND URETHANES[a]

Type, Density[b] →	Epoxy (prefoamed)		Phenolic (foam-in-place)		Urethane (foam-in-place)			
	5-10	13-20	2-5	7-10	0.5-5	6-9	12-15	18-25
Compr Str, psi	90–260	440–1080	9–31	45–130	2–120	150–250	350–800	900–1800
Ten Str, psi	51–180	360–650	4–35	35–75	10–150	150–300	300–600	700–1200
Flex Str, psi	210–420	570–940	24–40	75–230	—	—	—	—
Shear Str, psi	—	—	8–30	40–135	2–100	120–200	180–550	7600
Ther Cond, Btu/hr/sq ft/°F/ft	0.022	0.024	0.020	0.023	0.01–0.03	0.012–0.03	0.014–0.03	0.015–0.03
Coef of Ther Exp, 10^{-6} per °F	2.2	1.6	—	—	1.5	2.0	4.4	5.0
Water Abs (vol), %	0.25–1.3	0.09–0.1	—	—	—	1.6[f]	0.6	0.2
Max Rec Svc Temp, F	—	—	300[c]	300[c]	250	350[f]	400	400
Flammability	—	—	Noninflammable		Self-extinguishing			
Dissip Factor	0.0001–0.0004	0.003–0.009	—	—	0.0005	0.001	0.002	0.003
Vol Res, ohm-cm	—	—	—	—	—	—	—	—
Dielec Str, v/mil	—	—	—	—	—	—	—	—
Dielec Const	1.19–1.36	1.46–1.55	—	—	1.05	1.15	1.25	1.40

[a] Chemically activated.
[b] Density in lb per cu ft.
[c] For intermittent exposure: 550 F.

Hard Rubber—Molded, Extruded

Type →	Molded Parts[a]								
	GP	GP	GP	GP	H Ht	H Ar	Ar Ht Wr, H DQ	H Ht, Ch	Ht Ma
PHYSICAL PROPERTIES[b]									
Specific Gravity	1.21	1.21	1.28	1.54	1.65	1.95	1.71	1.24	1.80
Water Absorption (24 hr), %	0.08	0.06	0.14	0.30	0.06	0.06	0.10	0.12	0.04
Color	Black	Black	Black	Black	Red-brown	Red-brown	Red-brown	Black	Black
MECHANICAL PROPERTIES									
Ten Str, 1000 psi	8.3	7.9	4.5	2	6.75	4	5.8	7.17	5.4
Elong (in 2 in.), %	4.00	4.00	3.40	2.00	2.60	1.00	2.60	2.70	1.80
Hardness (Rockwell)	B108-76	B107-91	B129-79	B103-27	B83-60	B65-41	B82-55	B115-85	B82-54
Hardness (durometer)	81-87	81-87	78-84	76-82	85-92	87-95	86-92	84-90	84-92
Impact Str (Izod notched), ft-lb/in.	0.48	0.45	0.45	0.27	0.35	0.32	0.38	0.41	0.34
Flex Str, 1000 psi	12.5	11.3	7.1	2.8	8.7	8.4	9.1	11.3	10
Heat Dist Temp, F	142	145	134	Low	283	300	246	275	295
ELECTRICAL PROPERTIES									
Dielec Str (60 cycles), v/mil	435	496	344	377	393	600	371	400	420
Dielec Const[c]	3.00	2.95	3.80	4.95	4.10	4.80	4.60	3.50	4.10
Dissip Factor[c]	0.8	0.7	1.2	2.8	1.2	2.5	1.2	1.6	1.8
Surface Res (74 F, 86% RH), megohms	4.8×10^5	$>10^8$	$>10^8$	5.08×10^5	5.32×10^5	—	4.46×10^4	2.0×10^3	8.02×10^4

Type →	Sheets[a]					Rods and Tubes[a]			
	GP	El[d]	H Ht	H Ht, Ch	St Fl, H DQ	GP	El	H Ht, Ch	St Fl, H DQ
PHYSICAL PROPERTIES[b]									
Specific Gravity	1.20	1.17	1.43	1.24	1.27	1.21	1.15	1.24	1.27
Water Absorption (24 hr), %	0.06	0.22	0.15	0.12	0.08	0.06	0.12	0.12	0.07
Color	Black	Black	Black	Black	Yellow-brown	Black	Black	Black	Yellow-brown
MECHANICAL PROPERTIES									
Ten Str, 1000 psi	9.3	2.55	7.4	7.17	7.45	9.7	3.6	7.17	6.5
Elong (in 2 in.), %	5.00	33.00	1.20	2.70	5.30	5.00	16.00	2.70	3.80
Hardness (Rockwell)	112-79	—	86-60	115-85	112-80	107-70	—	115-85	112-80
Hardness (durometer)	80-86	50-60	86-92	84-90	80-86	80-86	65-75	84-90	80-86
Impact Str (Izod notched), ft-lb/in.	0.48	0.51	0.53	0.41	0.50	0.48	0.48	0.41	0.52
Flex Str, 1000 psi	16.6	—	9.64	11.3	14.95	11.375	—	11.3	9.06
Heat Dist Temp, F	159	Low	221	275	150	163	Low	275	217
ELECTRICAL PROPERTIES									
Dielec Str (60 cycles), v/mil	487	437	613	400	415	524	512	400	374
Dielec Const[c]	2.95	3.00	3.25	3.50	3.70	2.90	3.15	3.50	3.60
Dissip Factor[c]	0.5	1.3	0.6	1.6	0.6	0.5	1.4	1.6	0.9
Surface Res (74 F, 86% RH), megohms	2.23×10^7	2.66×10^4	$>10^8$	2.0×10^3	7.98×10^4	$>10^8$	$>10^8$	2.0×10^3	6.73×10^4

[a]GP = general purpose, H = high, HT = heat resistance, Ar = arc resistance, Wr = wear resistance, DQ = dielectric quality, Ch = chemical resistance, MA = low moisture absorption, El = elongation, St = strength, Fl = flow resistance. These designations are arbitrary abbreviations of principal properties and are not standard.

[b]Hard rubber in general has a thermal coefficient of linear expansion of 0.00004 per °F.

[c]Frequency: 1 kc-1 mc.

[d]Semihard.

Rubber—Molded, Extruded

Type →	Natural Rubber	Butadiene-Styrene (GR-S)	Butadiene-Acrylonitrile (nitrile)	Chloroprene (neoprene)	Butyl (isobutylene-isoprene)
PHYSICAL PROPERTIES					
Specific Gravity	0.93	0.94	1.00	1.25	0.90
Ther Cond, Btu/hr/sq ft/°F/ft	0.082	0.143	0.143	0.112	0.053
Coef of Ther Exp (cubical), 10^{-5} per °F	37	37	39	34	32
Electrical Insulation	Good	Good	Poor	Fair	Good
Flame Resistance	Poor	Poor	Poor	Good	Poor
Min Rec Svc Temp. F	-60	-60	0	-40	-50
Max Rec Svc Temp, F	180	180	250	240	300
MECHANICAL PROPERTIES					
Ten Str, psi					
Pure Gum	2500-3500	200-300	500-900	3000-4000	2500-3000
Black	3500-4500	2500-3500	3000-4500	3000-4000	2500-3000
Elongation, %					
Pure Gum	750-850	400-600	450-700	800-900	750-950
Black	550-650	500-600	450-650	500-600	650-850
Hardness (durometer)	A30-A90	A40-A90	A40-A95	A40-A95	A40-A90
Rebound					
Cold	Excellent	Good	Good	Very good	Bad
Hot	Excellent	Good	Good	Very good	Very good
Tear Resistance	Excellent	Fair	Good	Fair to good	Good
Abrasion Resistance	Excellent	Good to excellent	Good	Good	Good to excellent
CHEMICAL RESISTANCE					
Sunlight Aging	Poor	Poor	Poor	Very good	Very good
Oxidation	Good	Good	Good	Excellent	Excellent
Heat Aging	Good	Very good	Excellent	Excellent	Excellent
Solvents					
Aliphatic Hydrocarbons	Poor	Poor	Excellent	Good	Poor
Aromatic Hydrocarbons	Poor	Poor	Good	Fair	Poor
Oxygenated, Alcohols	Good	Good	Poor	Poor	Very good
Oil, Gasoline	Poor	Poor	Excellent	Good	Poor
Animal, Vegetable Oils	Poor to good	Poor to good	Excellent	Good	Excellent
Acids					
Dilute	Fair to good	Fair to good	Good	Excellent	Excellent
Concentrated	Fair to good	Fair to good	Good	Good	Excellent
Permeability to Gases	Fair	Fair	Fair	Low	Very low
Water Swell Resistance	Fair	Excellent	Excellent	Fair	Excellent
USES	Pneumatic tires and tubes; power transmission belts and conveyor belts; gaskets; mountings; hose; chemical tank linings; printing press platens; sound or shock absorption; seals against air, moisture, sound and dirt		Carburetor diaphragms, self-sealing fuel tanks, aircraft hose, gaskets, gasoline and oil hose, cables, machinery mountings, printing rolls	Flexible petroleum tubes and hoses, petroleum and chemical tank linings; electrical insulation in contact with oil, flashlight cases, electrical sockets, special truck tires	Truck and automobile tire inner tubes, airing bags for tire vulcanization and molding, steam hose and diaphragms, flexible electrical insulation

Rubber—Molded, Extruded

Type →	Polysulfide (Thiokol)	Silicone (polysiloxane)	Urethane (diisocyanate polyester)	Fluorinated Acrylic (dihydroperfluoro-butylacrylate)	Viton (vinylidene fluoride-hexafluoropropylene)
PHYSICAL PROPERTIES					
Specific Gravity	1.35	1.25	1.25	1.5	—
Ther Cond, Btu/hr/sq ft/°F/ft	—	0.11-0.12	—	—	—
Coef of Ther Exp (cubical), 10^{-6} per °F	—	67	—	—	—
Electrical Insulation	Fair	Excellent	Fair	Good	Excellent
Flame Resistance	Poor	Fair	Good	Good	Good
Min Rec Svc Temp, F	−60	−120	−65	0	−50
Max Rec Svc Temp, F	250	550	240	450	450
MECHANICAL PROPERTIES					
Ten Str, psi					
Pure Gum	>1000	600–1000	>5000	1200	>2000
Black	—	—	—	—	—
Elongation, %					
Pure Gum	450–650	60–400	540–750	300	>350
Black	—	—	—	300	—
Hardness (durometer)	A40–85	A40–85	A35–100	A55	A60–90
Rebound					
Cold	Good	Excellent	Bad	—	Good
Hot	Good	Excellent	Good	—	Excellent
Tear Resistance	Poor	Poor	Good	Poor	Fair
Abrasion Resistance	Poor	Poor	Excellent	Poor	—
CHEMICAL RESISTANCE					
Sunlight Aging	Very good	Excellent	Excellent[a]	Good	Excellent
Oxidation	Very good	Very good	Very good	Good	Excellent
Heat Aging	Fair	Outstanding	Excellent[a]	Good	Outstanding
Solvents					
Aliphatic Hydrocarbons	Excellent	Poor	Excellent	Excellent	Excellent
Aromatic Hydrocarbons	Excellent	Poor	Excellent[b]	Excellent	Excellent
Oxygenated, Alcohols	Very good	Fair	Poor	Good	Poor
Oil, Gasoline	Excellent	Fair	Excellent	Excellent	Excellent
Animal, Vegetable Oils	Excellent	Excellent	Excellent	Excellent	Excellent
Acids					
Dilute	Good	Excellent	Fair	Excellent[c]	Excellent
Concentrated	Good	Fair	Poor	Excellent[d]	Good
Permeability to Gases	Extremely low	Fair	Excellent	Fair	—
Water Swell Resistance	Excellent	Excellent	Excellent	Poor	Excellent
USES	Seals, gaskets, diaphragms, valve seat disks, flexible mountings, hose in contact with solvents, balloons, boats, life vests and rafts	Wire and cable covering, gaskets, tubing, diaphragms, vibration mountings, rollers, insulators, valve seats and closures	Fork lift truck wheels, airplane tail wheels, back-up wheels for turbine blade grinders, spinning cots for glass fiber, hydraulic accumulators, shoe heels	O-rings; V-rings; diaphragms; special applications involving contact with halogenated solvents, organic phosphates and carbon tetrachloride	Critical seals, gaskets, diaphragms, flexible mounts, coated fabrics, etc., for service in chemical and thermal environments

[a] Discolors, but no change in properties.
[b] For up to 80% aromatics.
[c] To diesters, 450 F.
[d] To fire resistant hydraulic fluids, 450 F.

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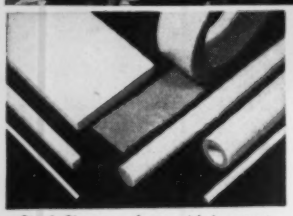

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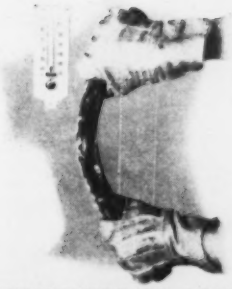

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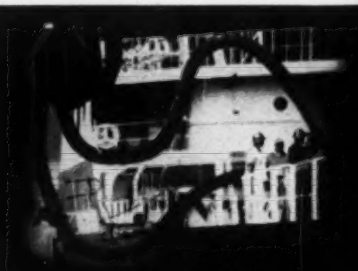

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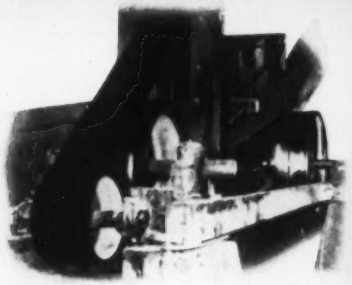

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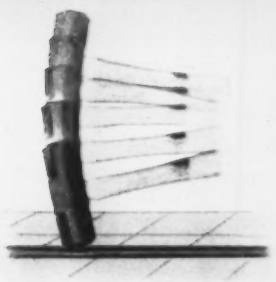

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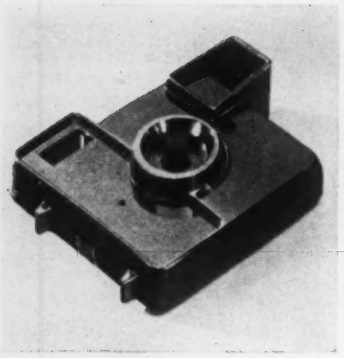

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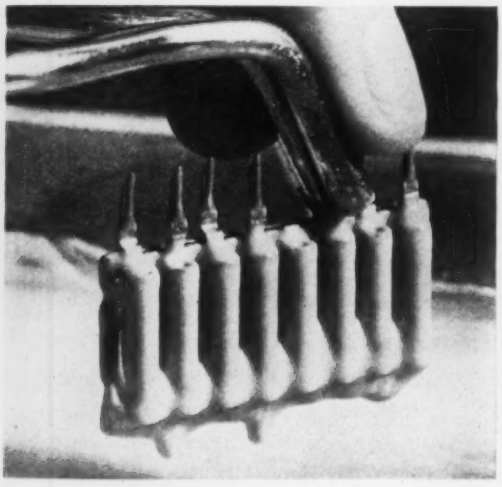

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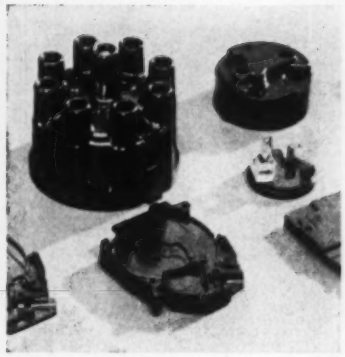
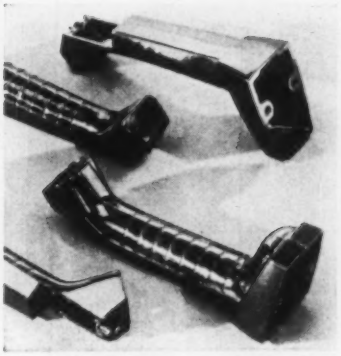
LARGE STRUCTURAL SHAPES such as this outboard motor shroud are stronger and safer when molded with Hetron® polyester resin and fibrous glass. Hetron laminates and molded parts do not support combustion. Fire resistance is inherent—chemically locked in without the use of weakening additives. Corrosion resistance, and the ability to take a baked-on finish without crazing, are other key qualities.

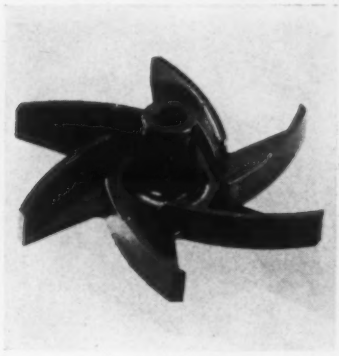
out tougher specifications...



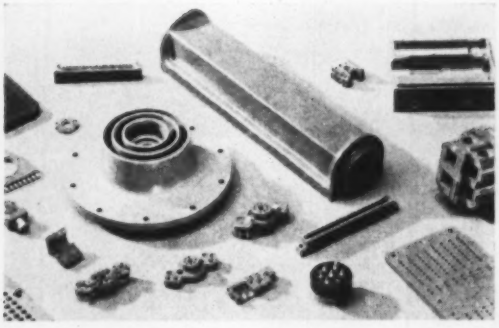
DESIRABLE ELECTRICAL PROPERTIES, combined with light weight and dimensional stability, can be obtained in Durez electrical grade phenolic molding compounds. They find wide use in automotive ignition parts, resistor casings, coil forms, tube bases, and electronic components of many types. Some of these compounds are formulated especially for molding around large inserts. Several are designed to meet military specifications.



HEAT RESISTANCE combined with high non-conductivity and other desirable electrical properties is also available in Durez molding compounds. Most compounds in this class are designed to take 72-hour heat-treatment at 392°F. Some will survive 450°F for relatively long periods, and higher temperatures for shorter periods, without serious impairment of physical properties or molded appearance. They find wide use in electrical appliances.



SPECIAL PROPERTIES in unusual combinations are available in Durez phenolics. Examples: low modulus of elasticity combined with other wanted properties. Or outstanding chemical and moisture resistance combined with high mechanical strength, as in this sump-pump impeller. By formula variations and the skills of compounding learned over a forty-year period, Durez can give you resins and molding compounds that fit any job.



SPACE-AGE PERFORMANCE often requires super-plastics such as Durez diallyl phthalate molding compounds. Reinforced with orlon or glass fiber, these materials are virtually free from cold flow and creep. They retain high electrical insulation values at relative humidities above 90% and over a wide temperature range. Their reliability has led to their wide use in rocket and missile components and in many other electrical and electronic systems.

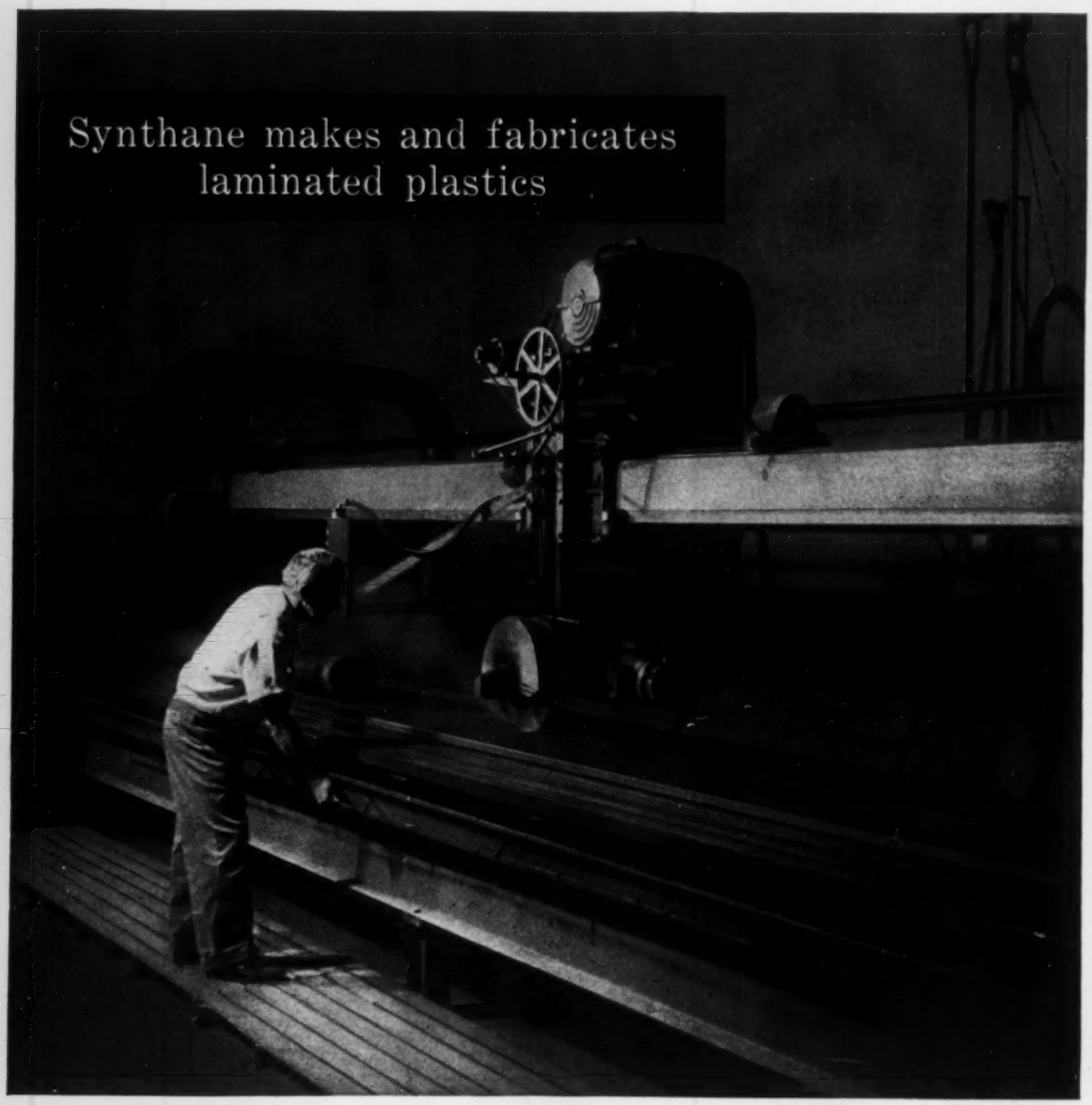
FACTS, IDEAS for your files are available in illustrated bulletins and data sheets. These contain full descriptions of Durez materials, including properties, uses, design suggestions, facts on molding and finishing. For latest application information, ask us to send you **Durez Plastics News,** mailed periodically, and packed with information on new products and uses.

DUREZ PLASTICS DIVISION

HOOKER CHEMICAL CORPORATION, 1414 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICALS PLASTICS

For more information, turn to Reader Service card, circle No. 410



Why "do-it-yourself" fabrication seldom pays

This is a "long length" saw, especially built to cut sheets of Synthane laminated plastics of over 25 feet in length.

It is extremely improbable that you would ever have sufficient work to make the purchase of such a machine profitable. Yet the long length saw is only one of hundreds of unusual machines necessary for fast, accurate, economical fabrication of laminates.

Without the advantage of special machines and tools, and faced with the possibility of errors, waste, delays, mistakes in tolerances or dimensions —at your expense—you may come to the same conclusion as have nearly all of our customers—buy your laminated plastics from us and have us fabricate them for you. Call any of our representatives—located in all principal cities—for a quotation or write to Synthane Corporation, 54 River Road, Oaks, Pa.

You furnish the print—we'll furnish the part

SYNTHANE
CORPORATION OAKS, PENNA.
Sheets • Rods • Tubes • Fabricated Parts
Molded-laminated • Molded-macerated

For more information, circle No. 444 ➤

For more information, turn to Reader Service card, circle No. 472

CYCOLAC®

Western Electric's new "Princess" telephone, made of CYCOLAC®

The **BORG-WARNER** Plastic

that is **TOUGH, HARD** and **RIGID**

MARBON CHEMICAL WASHINGTON — MARBON B-W CHEMICAL — Division **BORG-WARNER** WEST VIRGINIA

CYCOLAC OFFERS

NEW DESIGN

THE ONLY PLASTIC THAT GIVES YOU ALL THREE OF THESE VITAL REQUIREMENTS!

TOUGHNESS...

CYCOLAC has proved its ability to withstand continued rough use, hard knocks and abuse. Football helmets are typical of the gruelling service this ABS material can take without damage.

HARDNESS...

CYCOLAC offers unusual hardness and high-gloss finish, and retains its appearance in spite of constant handling and use. Office machines and telephones retain their smooth surface and glossy appearance almost indefinitely.

RIGIDITY...

CYCOLAC is resistant to flexure . . . maintains its original shape under load. Furthermore it is chemically resistant and dimensionally stable over a wide temperature range. This makes it suitable for a great variety of appliances, including floor washers.

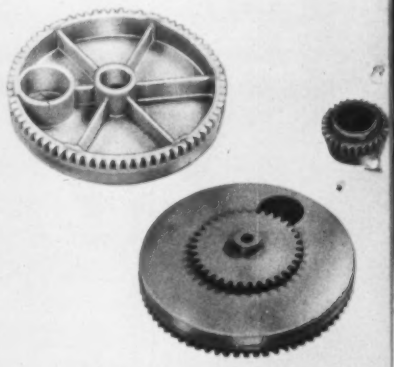
CYCOLAC OFFERS YOU ALL OF THESE

GOOD ELECTRICAL PROPERTIES...

The low water absorption of CYCOLAC, its uniform dielectric constant and power factor are basic properties needed in many electrical applications, including this automotive spark plug tester.

RESISTANCE TO CHEMICALS & STAINS

CYCOLAC is corrosion-resistant, offers protection against alkalies, salt solutions, oils, many acids, most household stains—makes fire extinguisher parts impervious to chemical action.



DIMENSIONAL STABILITY...

CYCOLAC contains no plasticizer to leach out. This factor, plus low water absorption, makes it ideal for precision end-use products and parts, such as these accurate coffee mill gears.

OPPORTUNITIES!

CYCOLAC is the registered trademark for ABS (acrylonitrile-butadiene-styrene) polymers manufactured by the Marbon Chemical Division of Borg-Warner. This lightweight, uniform resin is specially suited for the manufacture of any product requiring superior-impact strength—even at low temperatures—heat resistance, good electrical properties, hard surface, dimensional stability and chemical resistance. CYCOLAC is available in a wide range of colors with a high gloss finish.

Because of the unique balance of mechanical, electrical and chemical properties, CYCOLAC offers manufacturers exceptional opportunities for improving the design, construction and appearance of their products with substantial production economies. This thermoplastic resin is readily injection molded, extruded or vacuum formed. It can be machined, threaded, sawed, milled, drilled, buffed, blanked, punched or sheared. Products of CYCOLAC take lacquering, enameling or printing readily, are easily vacuum metallized, and can be bonded or laminated.

Marbon Chemical is also a major producer of paint and rubber resins and TY-PLY® rubber-to-metal adhesives.

CYCOLAC® OPENS BROAD NEW VISTAS IN MANUFACTURING ECONOMY BECAUSE IT CAN BE...

MOLDED

CYCOLAC is an excellent material for injection molding applications. It is readily molded into simple or complex parts and shapes, large and small. The inherent quality and outstanding characteristics of this resin insure greater product uniformity in manufacture and performance, exceedingly fine appearance and increased saleability.

EXTRUDED

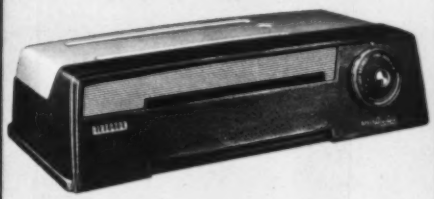
CYCOLAC is extruded into sheet, tubing and profiles and is a major material in the field of rigid pipe. Extrusions of CYCOLAC have unusual durability and strength, dimensional stability, and high gloss. Whatever the need, whatever the specification, designers and engineers find CYCOLAC superior in many ways.

VACUUM FORMED

The unique properties of CYCOLAC enable designers and engineers to use the economical vacuum forming process to eliminate large, costly metal fabrications. Postforming of extruded or calendered sheet is readily achieved by any conventional vacuum, air-pressure or mechanical method. Gauge control is easy and embossing is retained.

PRODUCT-IMPROVING ADVANTAGES

WIDE COLOR RANGE...
CYCOLAC is available in hundreds of different colors—solids or tints, bright or light—adding instant visual appeal to any end use product, including durable, attractive telephone units.



HIGH GLOSS FINISH...
Because of its long-lasting, high-gloss finish and greater sales appeal, CYCOLAC lends itself to quality products, including office equipment, appliances and toys.

LIGHTWEIGHT...
CYCOLAC is the lightest of all truly rigid thermoplastics, with a specific gravity as low as 1.02. Lightweight and rigid, despite hot or cold temperature extremes, this material is ideal for products like this airline meal tray carrier.

CYCOLAC® ...YOUR KEY TO NEW FUNCTIONAL

(A)

(A) LIGHTER, STRONGER LUGGAGE...

CYCOLAC makes possible the economical production of attractive, durable luggage. This easily-worked plastic permits soft contours and use of unusual and unique patterns in design.

(B) COMPACT AUTO AIR CONDITIONER...

Because of its strength, rigidity and lightweight, CYCOLAC is ideally suited for use in auto air conditioners. Rapid molding cycles, plus relatively low tooling costs for parts made of CYCOLAC, make it possible to gain substantial economies over other materials.

(C) CORROSION-RESISTANT SPRINKLER HEADS

Made of CYCOLAC, these sprinkler heads are designed to perform under extremes of climatic conditions without corrosion or major effect from sun or weather.

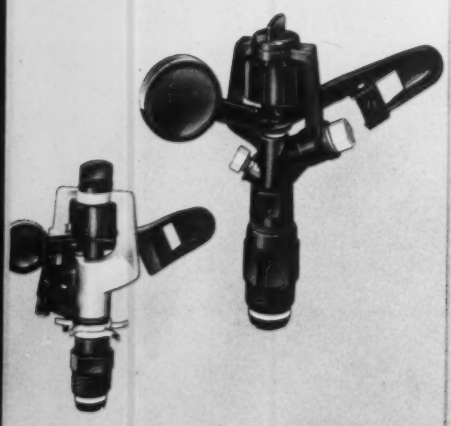
(D) BREAK-RESISTANT SHOE HEELS...

Fashionable high heels require maximum resistance to flexural fatigue failure plus resistance to breakage from sudden shocks, even at low temperature. CYCOLAC GS was specifically designed to meet these requirements.

(E) EASY-TO-CARRY GOLF CADDY...

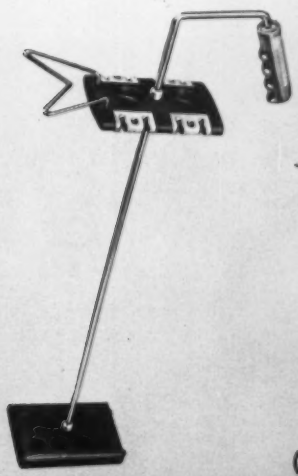
An interesting application of CYCOLAC is this easy-to-carry golf caddy. CYCOLAC was specified because of its unique combination of toughness and lightweight—a combination of properties essential to all sporting goods equipment.

(B)



(C)

(D)



(E)

BEAUTY AND SOUND PRODUCT DESIGN!

Look at these leading industries now using Cycolac...

Automotive • Radio and TV • Footwear

• Air Conditioning • Home Appliance

• Domestic and Commercial Refrigeration

• Office Equipment and Furniture

• Lawn and Garden Equipment

Telephone • Sporting Goods • Luggage

• Toy • Electrical • Power Mower

• Industrial Pipe and Fitting

• Hardware and Housewares • Photo and Safety Equipment • CYCOLAC also has many Military uses

APPEALING FLOOR WASHER...

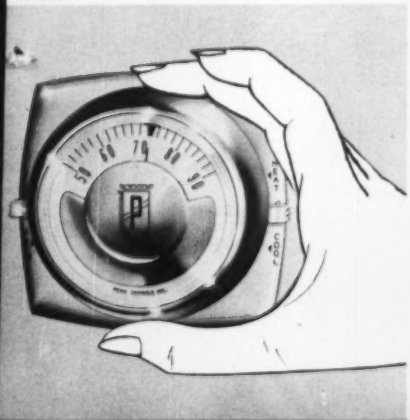
Fifteen key parts made of CYCOLAC contributed to the economy, appearance and performance of this new, popular home appliance.

STAIN-RESISTANT BLENDER CONTAINER..

Even coffee, mustard and grape juice have no staining effect on products made of CYCOLAC.

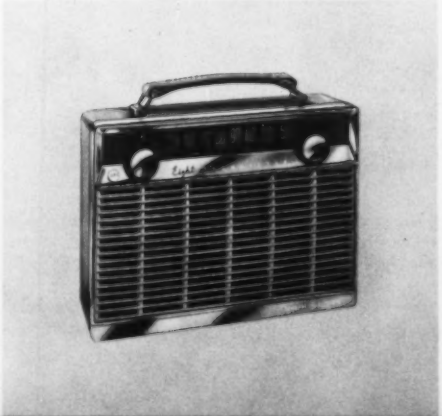
DEPENDABLE, PRECISION THERMOSTAT...

Housing molded of CYCOLAC is dimensionally stable under tension and offers good insulating properties.



SHOCK, DROP-RESISTANT RADIO...

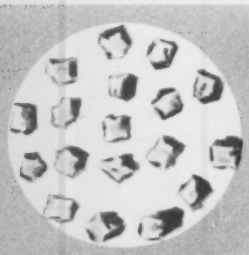
Case made of CYCOLAC combines stylish appearance with maximum protection for delicate electrical components.



CHECK AND COMPARE THESE PROPERTIES OF CYCOLAC

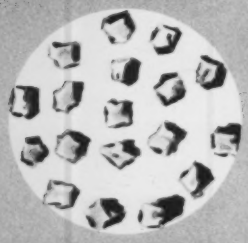
see why CYCOLAC is better in more ways than any other plastic!

6 TYPES GIVE YOU AN UNPARALLELED COMBINATION OF VALUABLE PROPERTIES!



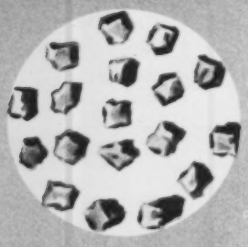
CYCOLAC T

For toughness with maximum hardness and tensile strength. Offers superior flow for injection molding of appearance parts with high surface gloss.



CYCOLAC H

For superior impact strength over wide temperature range in injection molded parts. Suitable for extruded sheet which can be readily vacuum formed.



CYCOLAC L

For intricate profile extrusions, calendered sheet and blending with PVC to facilitate processing and increase properties.

CYCOLAC C

For use in Type II ABS rigid plastic pipe. Displays superior long-term fiber stress and excellent high temperature performance.

CYCOLAC LL

For use in Type I ABS rigid plastic pipe. Displays a maximum of impact strength, even at low temperatures.

CYCOLAC GS

Especially designed for women's shoe heels which require a high resistance to flex fatigue and a good balance of physical properties. Provides excellent tensile strength, rigidity, heat resistance and impact strength at room or low temperatures.

CHEMICAL PROPERTIES CYCOLAC resins are almost completely resistant to aqueous acids, alkalies and salts. Concentrated sulfuric and nitric acids produce disintegration but concentrated phosphoric and hydrochloric acids have little effect. Low KB solvents, alcohols, and animal, vegetable and mineral oils produce insignificant changes.

Glacial acetic acid, carbon tetrachloride, aromatic hydrocarbons and high KB solvents cause marked swelling. Esters, ketones, and ethylene dichloride are solvents for CYCOLAC.

(ASTM D543-56T IMMERSION TEST)

PROPERTIES OF CYCOLAC RESINS

PROPERTY	TYPE OF RESIN						TEST METHOD
MECHANICAL	**LL** Black Only	**L**	**H**	**GS**	**T**	**C** Black Only	**ASTM**
Tensile Strength,[2] psi 160°F	2,900	2,900	2,900	3,800	3,800	4,600	D638-58T
73°F	5,100	5,100	5,100	6,700	6,400	7,800	
−40°F	7,800	7,800	7,800	9,600	9,400	11,500	
Tensile Modulus,[2] psi 73°F	210,000	210,000	210,000	310,000	280,000	340,000	D638-58T
Flexural Strength[1]							
160°F, 73°F, −40°F	No failure	No failure	No failure	No failure	No failure	No failure	D790-59T
Flexural Yield 160°F	5,100	4,600	4,400	5,900	5,900	6,900	
Strength,[1] psi 73°F	8,000	7,800	7,500	10,000	10,000	10,800	D790-59T
⅛"x1"x4" bar −40°F	11,800	11,800	11,800	15,000	15,000	18,500	
Flexural Modulus,[1] psi 160°F	190,000	190,000	190,000	240,000	240,000	310,000	
⅛"x1"x4" bar 73°F	240,000	240,000	240,000	310,000	310,000	370,000	D790-59T
−40°F	260,000	260,000	260,000	360,000	360,000	420,000	
Rockwell Hardness[1]	R86	R86	R87	R101 M10	R101 M10	R108 M35	D785-51
Specific Gravity[1]	1.04	1.02	1.02	1.04	1.04	1.06	
Wear Index, Taber Volume Loss Method CS-17 wheel, 1000g weight 73°F, 50% R.H.	25.5	23.0	22.7	20.1	18.8	22.8	
Water Absorption, % increase 24 hours, 73°F	0.2-0.3	0.2-0.3	0.2-0.3	0.2-0.3	0.2-0.3	0.2-0.3	D570-59T
IMPACT STRENGTH	**LL** Black Only	**L**	**H**	**GS**	**T**	**C** Black Only	**ASTM**
Izod Impact Strength ft. lb./inch notch	⅛" bar[1]	⅛" bar[2]	⅛" bar[2]	⅛" bar[2]	⅛" bar[2]	⅛" bar[2]	D256-56 Method A
Unnotched 73°F	>40.0	38.0	34.0	>40.0	30.0	29.0	
Notched 73°F	7.5-9.5	6-8	5-7	4-6	3-5	4-5	
−20°F	4.5	3.0	2.0	2.3	1.4	0.9	
−40°F	2.5	2.0	1.5	1.5	1.0	0.7	
Charpy Impact Strength[1] ft. lb./inch notch	¼" bar[1]	¼" bar[1]	¼" bar[1]	¼" bar[1]	¼" bar[1]	¼" bar[1]	D256-56 Method B
Unnotched 73°F	>40.0	>40.0	>40.0	33.0	26.5	>40.0	
Notched 73°F	7.5	6.2	4.9	4.0	3.4	3.4	
−20°F	4.0	3.2	2.3	2.3	1.6	1.3	
−40°F	3.2	2.7	2.0	1.5	1.5	1.0	
THERMAL	**LL** Black Only	**L**	**H**	**GS**	**T**	**C** Black Only	**ASTM**
Deflection Temperature[1], °F, 264 psi	196	196	196	198	198	215	
½"x½"x5" bar 66 psi	208	208	208	212	212	227	D648-56
(unannealed) Zero Load	223	223	220	220	220	238	
Deflection Temperature[1], °F 264 psi	224	224	220	219	219	232	
½"x½"x5" bar 66 psi	230	230	225	224	224	236	
(annealed) Zero Load	241	241	231	229	229	244	
Coefficient of Linear Thermal Expansion[1], in/in/°C.	$10.1x10^{-5}$	$10.1x10^{-5}$	$10.4x10^{-5}$		$8.9x10^{-5}$	$7.8x10^{-5}$	D696-44
Thermal Conductivity[1]							
Btu/hr./ft.²/°F/in.	1.35	1.46	1.46		1.54	1.80	C177-45
Cal/sec./cm²/°C/cm	$4.64x10^{-4}$	$5.05x10^{-4}$	$5.05x10^{-4}$		$5.30x10^{-4}$	$6.20x10^{-4}$	
Flammability[1], in/min ⅛" thick bar	1-1.5	1-1.5	1-1.5	1.5-2.0	1-1.5	1-1.5	D635-56T
Deformation under load[1], % 24 hr./122°F/2000 psi	1.60	1.35	1.38		0.81	0.41	D621-59
Mold Shrinkage[2], %	0.5	0.5	0.5	0.5	0.5	0.5	D955-51
ELECTRICAL	**LL** Black Only	**L**	**H**	**GS**	**T**	**C** Black Only	**ASTM**
Dielectric Constant[1]							
60 cycles	3.20	2.86	2.87		2.91	3.24	D150-59T
10^3 cycles	3.12	2.85	2.86		2.91	3.21	
10^6 cycles	2.90	2.77	2.76		2.44	3.11	
Power Factor[1]							
60 cycles	.005	.005	.005		.005	.005	D150-59T
10^3 cycles	.007	.006	.006		.006	.006	
10^6 cycles	.014	.008	.009		.008	.012	
Volume Resistivity[1], ohm-cm	$>3.54x10^{16}$	$>3.92x10^{16}$	$>3.80x10^{16}$		$>3.96x10^{16}$	$>3.57x10^{16}$	D257-58
Arc Resistance[1], Sec	50	71	71		82	87	D495-58T

[1]Compression Molded

[2]Injection Molded

The results given are based upon tests which we believe to be reliable. Due to varying conditions and methods of processing, we cannot guarantee results to be obtained. Nothing contained in this brochure is intended as a recommendation to use our products so as to infringe on any patents.

CYCOLAC®

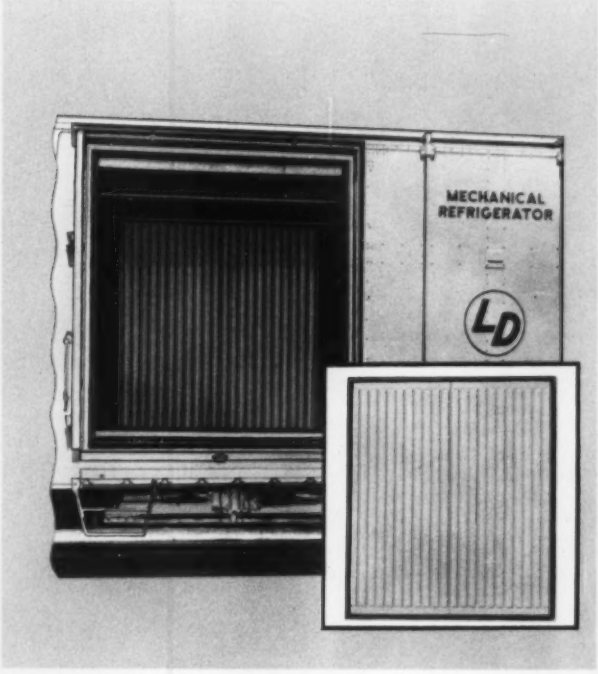
. . . the versatile plastic for use in applications from typewriters to refrigerator car door liners

REMINGTON RAND FEATURES HOUSINGS OF CYCOLAC FOR STANDARD AND PORTABLE TYPEWRITERS . . .

Remington Rand wanted a superior material for the housing of their new standard and portable typewriters—one as advanced as the machine itself. The material had to be light in weight to make the typewriter easy to carry . . . stain-resistant . . . tough enough to resist cracking under impact . . . durable enough to withstand rough daily use in home or office . . . and economical to meet competitive prices. Remington Rand found what they wanted in CYCOLAC.

CYCOLAC MAKES HISTORY! WORLD'S LARGEST VACUUM-FORMED PART USED FOR REFRIGERATOR CAR DOOR LINERS . . .

Giant door shells, vacuum-formed of CYCOLAC plastic, are now used on the Pacific Fruit Express mechanical refrigerator cars. The use of CYCOLAC in these cars—developed to transport frozen foods at low temperatures—clearly demonstrates the ability of this versatile plastic to resist the effect of impact at sub-zero temperatures. These doors, supplied by Landis Industrial Company, reduced the weight—another important consideration for the transportation industry. In addition, CYCOLAC provided manufacturing economies and excellent moisture resistance which protects the insulating material. In service, door liners of CYCOLAC stand up under the roughest conditions.

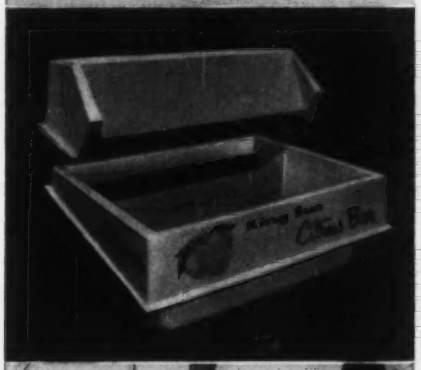


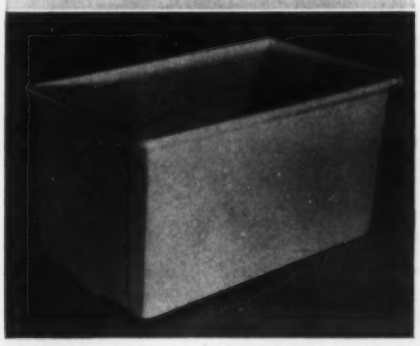
MARBON CHEMICAL
WASHINGTON

MARBON B-W CHEMICAL

DIVISION **BORG-WARNER**
WEST VIRGINIA

Printed in U.S.A.





Data Sheet
CAMPCO
Thermoplastic Sheet and Film

Campco Sheet and Film has demonstrated exceptional quality and dependability in thousands of applications. The data which follows indicates the characteristics and qualities of each type, enabling you to match them with the requirements of your product. If further information is desired, we shall be glad to supply it.

STYRENES

S-540 Styrene—Rubber modified rigid alloy. High impact strength and dimensional stability. Low moisture absorption, good heat resistance. Vacuum form. Gauges .010″ to .187″ stock or custom sheets. Colors, translucent or opaque. For display, toys, trays, packaging, housewares, luggage, housings, cabinets, tote boxes.

S-300 Styrene—Similar to S-540 but with greater rigidity. Good impact strength.

S-1029 Tripolymer Styrene—High impact, tensile and flexural strength at extreme temperatures. Excellent chemical resistance and dimensional stability, low moisture absorption. Forms easily, machines readily. In smooth or Haircell grain finish, gauges .020″ to .125″, many colors. For luggage, housings, chairs, ducts, exhaust hoods, clock cases.

ACETATE

A-130 Cellulose Acetate—Strong and tough. Vacuum or pressure form. Machines well. In gauges .003″ to .060″ transparent, translucent, opaque, clear and colors. For blister packs, wraps, displays, toys, novelties, indoor signs.

POLYETHYLENE

PE-200 Linear Polyethylene—Rigid, tough, heat and chemical resistant with good dielectric properties. Forms, machines, welds. Gauges .020″ to .125″ custom sheets and rolls. For housewares, containers, vessels, electrical products, toys, housing, packaging.

PE-100 Low Density Polyethylene—Low melt viscosity, excellent chemical and heat resistance. Stable under humidity changes. Vacuum form. Processes rapidly. In gauges .015″ to .125″ gloss finish custom sheets and rolls. For housewares, packaging, toys, containers, form liners, electronic applications.

POLYPROPYLENE

PP-300 Polypropylene—Impervious to stress cracking. Excellent dielectric properties, chemical resistance, rigidity, strength. Heat resistant to 300° F. Low specific gravity. Gauges .010″ to .250″ custom sheets and rolls, variety of colors. For chemical ducts and vats, fittings, electrical parts, sterile items.

Campco engineers will gladly work with you on any problem involving the use of these materials. Write or phone today. There is no obligation.

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CHICAGO MOLDED PRODUCTS CORPORATION
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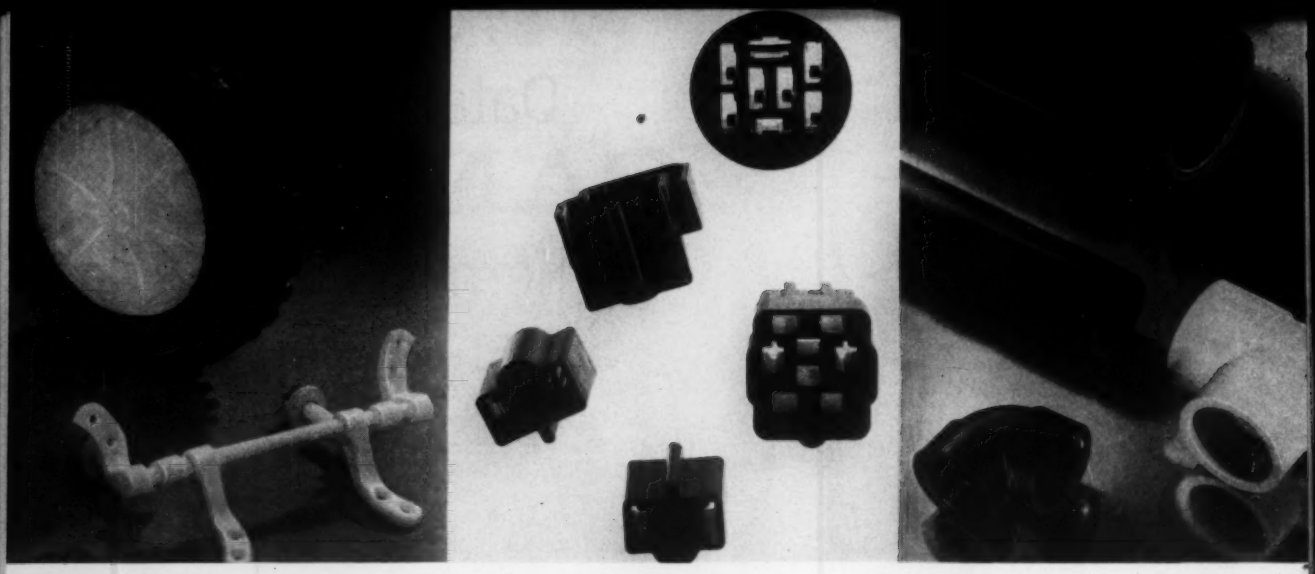

Meet AviSun Polypropylene. The structure and molecular weight of this new thermoplastic can be tailored to make a variety of end products, including: hospital and laboratory ware; appliances; automotive and aircraft parts; housewares; toys; containers; closures; electrical items; fibers; rope and packaging film.

LIGHTEST of all plastics. Up to 50% more molded parts per pound.
HIGHLY HEAT RESISTANT . . . with a melting point of 330° to 340°.
MOST RIGID of the polyolefins, plus high surface gloss and abrasion resistance.
EASY PROCESSING by various means: injection molding, blow molding, extrusion, vacuum forming and film and sheet extrusion.

AVISUN*

CHARACTERISTICS

CHEMICAL performance is excellent. End products are highly resistant to detergents and other stress cracking agents. The material resists most acids, including hydrochloric and sulphuric, as well as alkalies even at elevated temperatures. Resists gasoline, motor oils, foods, and plating, pickling and salt solutions. At high temperatures Polypropylene will swell in solvents such as toluene, carbon tetrachloride and also oxidizing acids. AviSun certifies that its polypropylene meets the conditions of F.D.A. regulation on the use of polypropylene for food packaging.

MECHANICAL—The stiffness modulus of polypropylene is greatest of all polyolefins, and puts polypropylene in the classification of "rigid" plastic materials. Retains strength and stiffness at elevated temperatures better than any competitive thermoplastic. Has high compressive strength and resistance to deformation at high temperatures. Toughness exceeds that of polystyrene at low temperatures. The tensile strength of Polypropylene is the highest of all the polyolefins. At normal test rates, molding grades will show elongations up to 500%.

ELECTRICAL—Being a nonpolar material it exhibits very low losses in alternating electrical fields. Its high heat distortion and softening temperature are ideal for many electrical uses. High volume resistivity and ease of extrusion make wire and cable insulation an important potential application. Its low dissipation factor makes it attractive for high frequency insulation. Low moisture absorption makes Polypropylene components electrically stable. Good mechanical and processing properties make the electrical characteristics even more desirable.

PHYSICAL — AviSun Polypropylene has a linear, ordered structure which can be highly crystalline. This "tailored" structure is reflected in its many unique properties. In addition, its chemical, mechanical and electrical behavior are generally improved over the known performance of other "isotactic" polyolefin structures. As the material becomes more highly crystalline, the tensile strength and modulus increase, but other qualities change somewhat as well. Therefore, AviSun Polypropylene has been formulated to an optimum balance of end properties.

TECHNICAL ASSISTANCE—AviSun Technical Specialists are at your service. They will answer your specific questions about AviSun Polypropylene . . . and help you plan better products at lower cost with this versatile new thermoplastic.

PHONE HUbbard 5-5831 or write

AVISUN CORPORATION
379 POST ROAD, MARCUS HOOK, PA.

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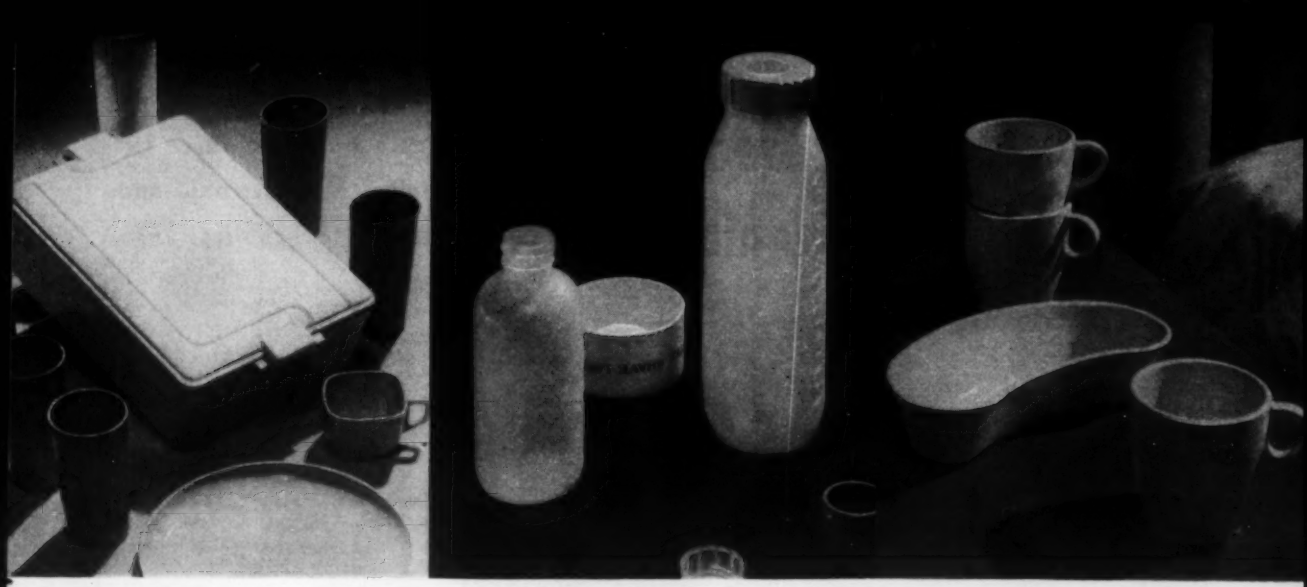

Polypropylene

the new thermoplastic . . . exciting new product opportunities!

PROPERTIES OF INJECTION MOLDING AND EXTRUSION GRADES

TABLE 1

Typical Physical Property Values

Property	A.S.T.M. Test Method	Units	Values: Extrusion Grade	Values: Injection Molding Grade
Tensile Yield Strength	D-638-58T (0.2 in./min.)	psi	4700	4900
Total Elongation	D-638-58T	%	300	400
Stiffness (flexural)	D-747-50	10^5 psi	1.8	1.8
Izod Impact	D-256-56	ft. lb./inch of notch	1.3	0.8
Hardness				
Shore	D-676-55T	D	74	74
Rockwell	D-785-51	R	75	80
Deformation under load—2000 psi, 122°F, 24 hrs.	D-621-51	%	3.2	3.2

TABLE 2

Typical Physical Property Values for Both Grades

Property	A.S.T.M. Test Method	Units	Values
Form	—	—	⅛" Pellets
Bulk Factor	D-1182-54	—	1.8
Specific Gravity	D-792-50 Method A	—	0.910-0.920
Refractive Index	—	n_D^{25}	1.510
Water Absorption	D-570-54T (24 hr. at 73°F)	%	nil
Heat Distortion	D-648-56	°F	
66 psi			240
264 psi	—		150
Flammability	D-635-56T		slow
Coefficient of Linear Thermal Expansion	D-696-44	10^{-5} in./°F	
46 to 154°F			6.7
97 to 205°F			8.9
Specific Heat	—	cal./°C/gram	0.45
Mold Shrinkage	—	in./in.	0.010-0.025
Environmental Stress Cracking	Bell Laboratory Method 100% Igepal	Years	>2

TABLE 3

Typical Electrical Property Values for Both Grades

Property	A.S.T.M. Method	Units	Values
Power Factor	D-150-54T		
at 10^2 cycles			<0.0007
at 10^3 cycles			0.0002
at 10^6 cycles			0.0002
Dielectric Constant	D-150-54T		
at 10^2 cycles			2.3
at 10^3 cycles			2.3
at 10^6 cycles			2.1
Dielectric Strength	D-149-55T (.032 in. thickness)		
Short Term @ 73°F		volts/mil	1040
Step by Step @ 73°F		volts/mil	950
Volume Resistivity	D-257-57T	ohm-cm	$>3\times10^{15}$
Surface Resistivity	D-257-49T	ohms	$>3.4\times10^{14}$

TABLE 4

Typical Chemical Properties for Both Grades

Chemical	% Weight Change After 30 Days Immersion @ 73°F
Distilled Water	+0.015
Inorganic Acids	
Sulfuric Acid 30%	+0.01
Nitric Acid 10%	+0.013
Hydrochloric Acid 10%	+0.013
Organic Acids	
Acetic Acid 5%	+0.022
Oleic Acid 93%	+0.04
Citric Acid 10%	+0.02
Alkalies	
Sodium Hydroxide 10%	+0.002
Sodium Hydroxide 1%	+0.009
Ammonium Hydroxide 10%	+0.03
Sodium Carbonate 2%	+0.024
Organic Solvents	
Ethyl Alcohol 95%	+0.048
Ethyl Alcohol 50%	+0.027
Acetone	+0.68
Ethyl Acetate	+2.84
Ethylene Dichloride	+7.84
Carbon Tetrachloride	+30.0
Toluene	+10.54
Heptane (boiling point)	+11.01
Phenol	+0.041
Other	
NaCl Solution 10%	+0.02
Hydrogen Peroxide 3%	+0.03

Taylor Laminated Plastics and Taylorite Vulcanized Fibre

Basic materials for electrical, electronic and mechanical applications

More than 50 grades to meet any requirement

Take your pick from paper, cotton cloth, nylon, asbestos, glass cloth or other base material impregnated with phenolic, melamine, silicone or epoxy resins and formed into sheets, rods and tubes under heat and pressure.

There is one grade that will fit your exact requirements—whether you need good electrical insulation, great structural strength, resistance to chemical reaction, resistance to heat and flame, ease of fabrication, or a combination of these characteristics.

Phenolic Laminates. Thermosetting type. Paper, cotton fabric or mat, asbestos, glass cloth or nylon bases impregnated with phenol formaldehyde type resins. Provide dependable electrical insulation, have high dielectric and mechanical strength. Some grades are excellent basic materials for gears, cams, pinions, bearings and other mechanical applications. Asbestos grades are qualified as Class B insulation; others meet Class A requirements.

Melamine Laminates. Thermosetting type. Glass cloth or cotton fabric impregnated with melamine formaldehyde resin. These laminates have superior mechanical strength and are especially desirable for their arc resistant qualities. Good flame and heat resistance and good resistance to the corrosive effects of alkalis and most common solvents are other favorable characteristics. Classified as Class B insulation.

Silicone Laminates. Thermosetting type. Continuous filament woven glass fabric impregnated with a silicone resin. These laminates combine high heat resistance (up to 500°F., continuous) with excellent electrical and mechanical properties. Have low power factor and moisture absorption rate; very high insulation resistance and high arc resistance; excellent dimensional stability and high tensile, flexural and impact strength. Classified as Class H insulation.

Epoxy Laminates. Thermosetting type. Continuous filament woven glass fabric or paper impregnated with epoxy resin. Combine low moisture absorption with excellent chemical resistance and high mechanical strength. Characterized by good dielectric strength, low dielectric losses, and high insulation resistance even after being subjected to severe humidity conditions. Can be copper clad for production of high fidelity printed circuits.

Copper-Clad Laminates. Offer a combination of high-purity copper on superior base materials to produce printed circuits of consistently high quality. Taylor copper-clad laminates are available in several phenolic resin, paper base grades, in epoxy resin, paper or glass cloth base grades, and in specially formulated grades to meet specific requirements. All grades meet or exceed military and NEMA standards. The copper cladding is 99.5% pure and free of pinholes, pits and lead inclusions—has a high-quality finish that accepts all acid resists. All Taylor copper-clad laminates are supplied with 1, 2 or 3-oz. copper on one or both sides.

Flame-Resistant Laminates. Flame-retardant paper base laminates made with special phenolic resin. Have excellent moisture resistance, high electrical resistance and good mechanical properties. Offer low dielectric losses. Meet tentative Underwriters' Laboratory requirements for flame retardance.

TAYLORITE VULCANIZED FIBRE

Taylorite Vulcanized Fibre is a hard, dense material with excellent physical, mechanical and electrical properties. It is tough and resilient; has high resistance to impact, abrasion, wear, organic solvents, oils and gasoline; can be machined, stamped, punched and formed; is attractive in appearance, light in weight. Available in a number of different grades, in sheets, rolls and turned rods: commercial, bone, electrical, trunk, superwhite, built-up, abrasive, flexible, track.

ADVANCED MATERIALS DEVELOPMENT

Taylor's Advanced Materials Division is organized to research and develop vulcanized fibre and laminated plastics for application in rockets, missiles, jet aircraft, and nuclear reactors, to name a few. It is set up to work on R&D programs for other concerns too, and also for Government agencies. It will develop special materials for particular applications when required.

ENGINEERING AND FABRICATING SERVICES

New applications for Taylor materials are constantly being developed by design and production engineers in the Taylor plants. These men are available for consultation. Their experience and counsel can help you in the development of your product. Taylor's fabricating division can economically produce parts from any of the above materials. Consult us for complete details on either one or both of these Taylor services. Technical engineering data on all these products available upon request. Write Taylor Fibre Co., Norristown 45, Pa.

Taylor

LAMINATED PLASTICS VULCANIZED FIBRE

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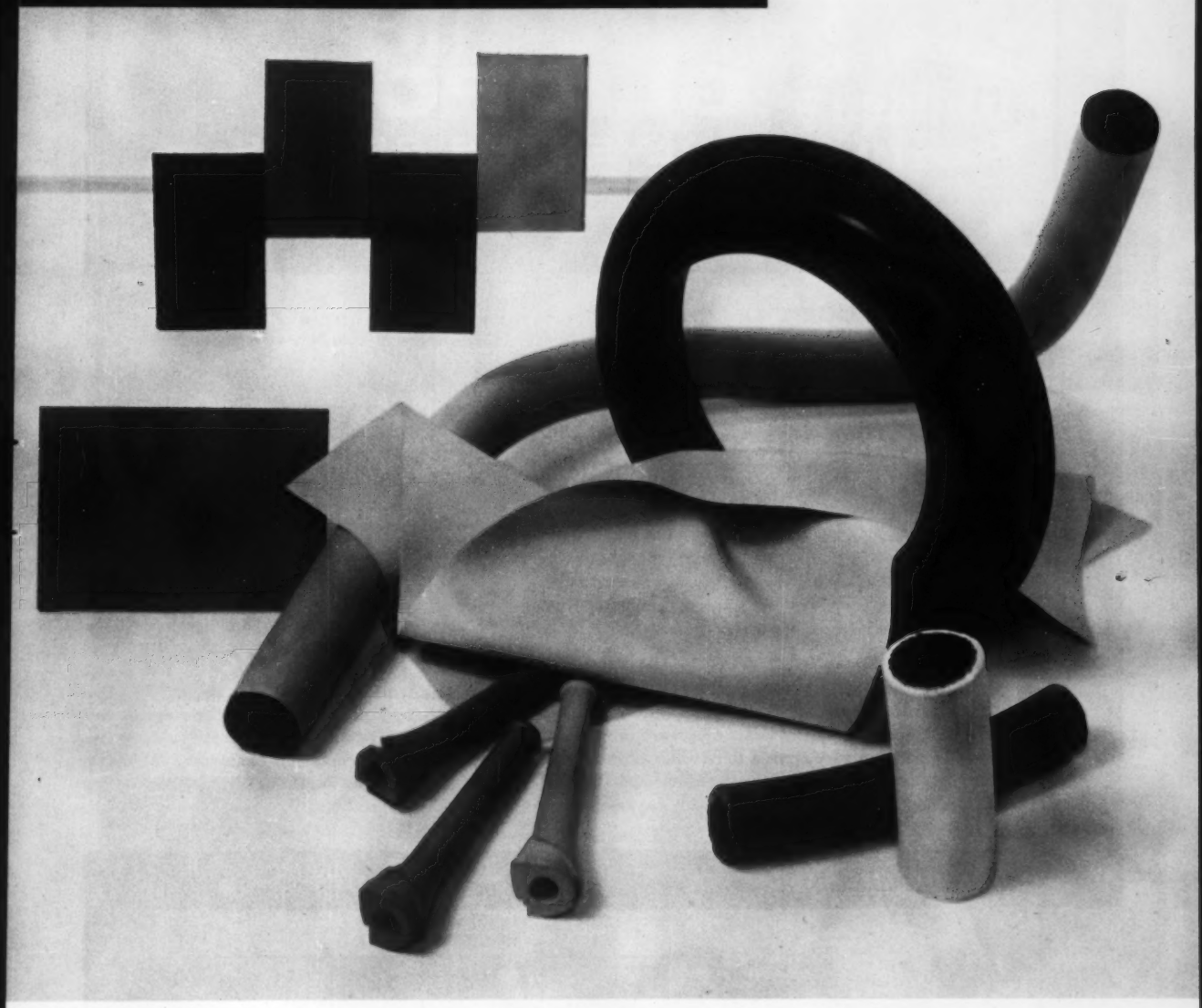
THE OIL-RESISTANT, OZONE-RESISTANT NITRILE RUBBER



...tough, oil-proof, weather-proof and **colorful, too!**

The samples above should begin to give you some idea of the endless color possibilities in ozone-resistant rubber products made of new PARACRIL® OZO. Now you can give your product color that *sells*... color that identifies for coding wire and cable jacketing... color that blends or *contrasts*... color that works in a hundred ways. And you can give your product other superior properties, too.

Along with color, new weather-resistant PARACRIL OZO gives you a combination of high abrasion resistance, oil resistance, flex life and other valuable rubber properties far surpassing conventional weather-resistant rubbers.

Cast a new eye on the rubber product you make or buy. See the difference color makes. See your Naugatuck Chemical Representative or write the address below for full information on PARACRIL OZO and the advantages it offers.

Naugatuck Chemical

Division of United States Rubber Company Dept. A Elm Street Naugatuck, Connecticut

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QUALITY Glidden PRODUCTS

GLIDPOL
POLYESTER RESINS

For Laminating, Impregnating, Molding, Casting and Protective Coating

GENERAL CHARACTERISTICS—The Glidpol polyester resins are basically solutions of linear polyester resins, produced by typical alkyd resin production methods, dissolved in solutions of reactive monomers. The linear polyesters are composed of mixtures of difunctional organic acids and alcohols. A certain portion of the acid component is made up of an unsaturated acid capable of reacting with the monomers and cross-linking adjacent polyester groups. Generally a higher concentration of unsaturated acid increases the unsaturation of the resin and gives a more reactive resin which is more rigid and less likely to deform at elevated temperatures.

Liquid and Cured Properties—The liquid resin properties vary depending on the process for which a particular product is designed. The principal differences in liquid characteristics are in viscosity—which can vary from a thin, watery consistency to a very thick or thixotropic state—and the particular curing characteristics depending on whether the material is designed to be cured at room temperature or in molds at temperatures as high as 300°F.

In the cured form, the resins differ in rigidity and hot strength and special characteristics which can be built in such as flame resistance, weathering resistance, chemical resistance, etc.

Compounding—In the majority of applications, Glidpol resins are compounded with a variety of reinforcing agents, granular fillers, and coloring pigments as required for the particular product being fabricated.

Curing—The Glidpol resins are cured by the addition of catalysts which are decomposed by heat or the addition of an accelerator to trigger the conversion of the resin to solid thermoset polymers which vary from flexible, rubber-like materials to rigid, tough solids. The resins are 100% reactive and give off no volatile by-products during cure, thus eliminating the necessity of venting or breathing the material during fabricating operations.

WHICH GLIDPOL RESIN TO USE

It is usually difficult to select the resin most suitable for any given fabricating requirement on the basis of physical properties alone. Even with considerable experience in what liquid and cured properties are required for a particular fabricating procedure, actual trials are often required to make a final selection from several possible resins and to pin down specific catalysts, curing times, temperatures, etc. The following tabulation can be used as a guide in selecting Glidpol resins for specific applications. This tabulation includes formulations which have proven themselves to be most suitable for current fabricating procedures. Our Plastics Laboratory is continually working on improved formulation which will do a better job for standard and new fabricating procedures. Data sheets on individual resin systems are available.

GLIDPOL POLYESTERS

	1001	1001-A	1001-LS	1008	1012	1017	1026	1027	1032	2002
Liquid Properties										
Styrene	X	X	X	X	X	X	X	X	X	X
Viscosity (1)	M	M	M	M	M	M	M	M		L
Thixotropic									X	
Curing Characteristics										
Preaccelerated for Room Temp. Cure									X	
Air Dry			Any with Glidpol 3305 added							
Cured Characteristics										
Flexible										X
Rigid	X	X	X	X	X	X	X	X	X	
High H.D.T.					X	X		X		
Light Stabilized			X							
Applications										
Casting and Potting	X	X		X						X
Contact Molding	X	X	X			X			X	
Matched Die Molding			X		X	X	X			
Premix Molding					X	X	X	X		
Laminating	X	X	X		X	X				
MIL-R-7575A	X				X	X				

(1) L—(low) 100-500 cps; M—(Medium) 500-3000 cps.

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12 grades for printed circuits...

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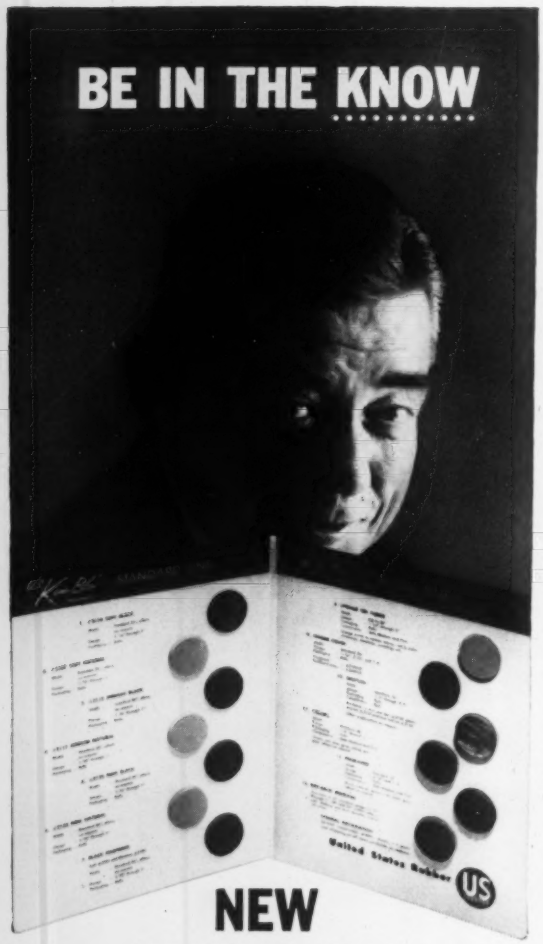

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Cymel molding compounds fill a variety of industrial and consumer applications – all have basic properties of surface hardness; non-flammability; resistance to heat, boiling water and attack by solvents; color stability; lack of odor or taste, and good electrical properties – for compression, transfer or plunger molding. *Military and Federal specifications are listed on technical data sheets, available on request.*

CYMEL 1077-1079 – alpha cellulose-filled – granular or powdered material available in extraordinary surface hardness – rich, lustrous look and feel – excellent chemical resistance – excellent electrical properties, including arc and track resistance . . . *dinnerware, buttons, electric mixer and shaver housings, closures, lighting fixtures.*

CYMEL 592 – asbestos-filled – granular material, available in brown only – excellent arc resistance and dielectric strength at elevated temperatures – dimensional stability – resistance to atmospheric extremes . . . *electronic equipment, aircraft and automotive ignition parts, circuit breakers, terminal blocks, switch gears.*

CYMEL 1500 – wood flour-filled – granular material, available in brown only – general purpose arc resistant electrical grade material – excellent dielectric strength . . . *watt-hour meter blocks, connector plug inserts, automotive ignition parts.*

CYMEL 1502 – cellulose-filled – granular material, available in brown only – particularly good dimensional stability and dielectric strength – excellent insert retention . . . *connector plug inserts, circuit breakers, automotive ignition parts, watt-hour meter blocks.*

CYMEL 3135 – glass fiber-filled – coarse-chopped material, natural color – electrical grade, high impact resistance – extraordinary flame resistance – arc resistant – low shrinkage and moisture absorption . . . *heavy duty switch gears, terminal strips and stand-off insulators, sockets and coil forms.*

CYMEL 3136 – glass fiber-filled – granular material, natural color – electric grade material with intermediate strength – excellent arc and insulation resistance – extraordinary flame resistance – low shrinkage and moisture absorption . . . *terminal strips and stand-off insulators, sockets and coil forms.*

CYMEL 3020 – cotton fabric-filled – chopped cotton, available in black only – electrical grade material with medium impact resistance – very good arc resistance, heat resistance and chemical resistance . . . *terminal strips, circuit breakers.*

CYMEL 404 – unfilled – highly translucent, may be tinted before molding – high surface luster . . . *decorative moldings including buttons and jewelry findings.*

		tests and conditioning procedures[AA]		Beetle alpha-urea	Cymel 1077-79 apha-mel.
	compression ratio (bulk factor)	loose-packed		2.5	2.1
	tabletting			excellent	excellent
	plasticity range			v. soft—hard	soft—med. hard
	moldability in compression molds			excellent	excellent
	compression molding temperature—°F			275—350	310—340
	compression molding pressure—psi			2,000—8,000	1,500—6,000
	moldability in transfer molds			special type	good
	transfer molding temperature—°F				300—320
	transfer molding pressure—psi			recommended	4,000—12,000
physical	shrinkage	D-955	A	.006—.009	.007—.009
	additional shrinkage—48 hours at 220°F	D-1299	A	.006—.012	.006—.008
	specific gravity	D-792	A	1.5	1.5
	molded density—grams/cubic inch			24.6	24.6
	machining quality			good	good
	thermal coefficient of expansion—linear/°C	D-696	A	22-36 x 10^{-6}	20—57 x 10^{-6}
	thermal conductivity—cals/sq. cm/sec/°C/cm	C-177	A	10.1 x 10^{-4}	10.1 x 10^{-4}
	heat distortion point at 264 psi—°F	D-648	A	266	410
	heat resistance (⅛" section—°F)			170	210
	flammability			self-exting.	self-exting.
	water absorption—24 hours at 25°C—%	D-570		0.4—0.8	0.1—0.4
	light—reflectance—% (.050" thick)	D-791		45.8	53.6
	transmission—% (.50" thick)	D-791		39.4	29.9
	resistance to sunlight			pastels grey	pastel yellow
	color possibilities			unlimited	unlimited
	impact strength; 120D, milled—ft. lbs./in	D-256	A	0.24—0.28	0.25—0.27
	compressive strength—psi	D-695	A	30,000—38,000	40,000—45,000
	rockwell hardness	D-785	A	E94—E97	E110
	shear strength (1" dia. slug)—psi	D-732		11,000—12,000	11,000—12,000
	flexural strength (¼" x ½" x 5" bar)—psi	D-790	A	11,000—18,000	10,000—15,000
	deflection (¼" x ½" x 5" bar)—inches	D-790	A	0.103—0.157	0.107—0.162
	modulus of elasticity—flexure—psi	D-790	A	1.4—1.5 x 10^{6}	1.3 x 10^{6}
	modulus of elasticity—tension—psi	D-638	A	1.3 x 1.4 x 10^{6}	1.35 x 10^{6}
	tensile strength—psi	D-638	A	5,500—7,000	7,000—8,000
electrical	dielectric strength				
	short time—volts/mil at 25°C	D-149	A	330—370	300—340
	—volts/mil at 100°C		A	200—270	170—210
	step by step—volts/mil at 25°C	D-149	A	220—250	250—290
	—volts/mil at 100°C		A	110—150	90—130
	slow rate of rise—volts/mil at 25°C	D-149	A	250—260	210—240
	—volts/mil at 100°C		A	120—170	90—120
	volume resistivity—ohms/cm	D-257	C	0.5—5.0 x 10^{11}	0.8—2.0 x 10^{12}
	surface resistivity—ohms	D-257	C	0.4—3.0 x 10^{11}	0.8—4.0 x 10^{11}
	insulation resistance	D-257	C	0.2—5.0 x 10^{10}	1.0—4.0 x 10^{10}
	dielectric constant—60 cycles	D-150	B	7.7—7.9	8.4—9.4
	—1,000,000 cycles		B	6.7—6.9	7.6—8.0
	dissipation factor—60 cycles	D-150	B	0.034—0.043	0.052—0.083
	—1,000,000 cycles		B	0.029—0.031	0.034—0.043
	dielectric loss factor—60 cycles	D-150	B	0.28—0.34	0.44—0.78
	—1,000,000 cycles		B	0.19—0.21	0.20—0.33
	arc resistance—seconds	D-495	A	80—100	120—128
	surface breakdown ratio	D-495	A	0.43—0.51	0.15—0.23
chemical	gasoline (hi-oct)—7 days immersion at 25°C	D-543		0	0
	lubricating oil (SAE 20)—7 days at 105°C	D-543		0	0
	1% H_2SO_4—7 days immersion at 25°C	D-543		attack	0
	1% naoh—7 days immersion at 25°C	D-543		discolors	0
	1% naoh—8 hours immersion, boiling	D-543		attack	discolors
	5% chromic acid—4 hours immersion at 25°C	D-543		attack	Sl. attack
	10% citric acid—7 days immersion at 25°C	D-543		attack	0
	acetone—7 days immersion at 25°C	D-543		0	0

note: the values above are obtained from laboratory prepared test pieces and may not be exactly reproducible in all cases in commercial practice

*water is 16.4 gms/cu. in.

^consult our technical department for details

properties

BEETLE® and CYMEL®

CYANAMID

Molding Compounds

Cymel 1500 wood fl.-mel.	Cymel 1502 alpha-mod. mel.	Cymel 3020 rag-mel.	Cymel 404 unfilled	Cymel 592 mineral-filled	Cymel 3135 glass-filled	Cymel 3136 glass-filled
2.4	2.7	10 (5 packed)	2.0	2.4	5-7	3—4.5
good	good	hand only	good	excellent	hand only	good
40—100 (extru)	40—100 (extru)	medium	medium	50—100 (extru)	medium	medium
excellent	excellent	very good	good	excellent	good	good
310—330	300—330	300—340	300—340	270—340	290—310	290—320
1,500—6,000	1,500—6,000	4,000—8,000	2,000—5,000	1,000—6,000	4,000	2,000—8,000
excellent	excellent	limited	limited	excellent	good	good
300—330	300—330	———	———	270—340	290—310	290—310
6,000—20,000	6,000—20,000	———	———	4,000—20,000	8,000—12,000	4,000—16,000
.007—.008	.006—.008	.003—.004	.010—.012	.005—.007	.002—.003	.002—.004
.004—.007	.001—.002	.004—.008	.007—.012	.002—.003	.002—.004	.003—.005
1.48—1.52	1.43	1.5	1.48	1.78	1.94—2.00	1.94—2.00
23.8	23.5	24.6	24.3	29.2	31.8—32.8	31.8—32.8
good	good	good	———	fair	poor	poor
32—50 x 10^{-6}	34—36 x 10^{-6}	25 x 10^{-6}	———	21—43 x 10^{-6}	12—20 x 10^{-6}	17—25 x 10^{-6}
8.4 x 10^{-4}	———	10.6 x 10^{-4}	———	13.1 x 10^{-4}	———	———
266	266	310	293	266	400	400
250	250	250	210	300	300	300
self-exting.	self-exting.	self-exting.	self-exting.	self-exting.	self-exting.	self-exting.
0.34—0.6	0.3—0.6	0.3—0.6	0.2—0.35	0.13—0.15	0.09—0.21	0.1—0.3
———	———	———	good	———	———	———
———	———	———	———	———	———	———
fades	fades	black only	good	fades	good	good
brown only	brown only	0.55—0.90	limited	brown only	natural	natural
0.25—0.38	0.30—0.42	30,000—35,000	0.14	0.30—0.40	4.0—6.0	0.5—0.7
30,000—35,000	24,500—26,000	E100	40,000—45,000	25,000—30,000	20,000—25,000	27,000—29,000**
E94	———	12,000—14,000	———	E90	———	———
10,000—10,500	11,500—12,000	12,000—15,000	———	7,000—8,000	———	———
6,500—9,000	9,000—12,000	0.033—0.132	9,500—13,000	7,400—10,000	16,400—24,000	13,200—17,400**
0.081—0.120	0.091—0.103	1.4 x 10^{6}	0.105—0.142	0.051—0.067	0.060—0.072	———
1.0 x 10^{6}	1.1 x 10^{6}	1.4 x 10^{6}	1.0 x 10^{6}	1.8 x 10^{6}	2.4 x 10^{6}	———
1.0 x 10^{6}	1.0 x 10^{6}	———	———	1.95 x 10^{6}	———	———
5,700—6,500	5,500—6,500	8,000—10,000	———	5,500—6,500	5,800	5,000—5,900**
350—370	350—390	250—340	300	410—430	170—240	320—370 (23°C)**
290—330	140—190	110—130	130	280—310	90—110	310—350 (50°C)**
200—240	200—250	220—240	240	280—300	170—220	170—270 (23°C)**
190—210	90—100	60—90	80	190—210	60—80	150—250 (50°C)**
240—260	280—290	210—240	———	270—290	170—210	———
170—200	90	70—80	———	170—190	70—90	———
6.0—10.0 x 10^{12}	6 x 10^{10}	1.0—3.0 x 10^{11}	———	1.2 x 10^{12}	2 x 10^{11}	9.2 x 10^{10}**
0.3—5.0 x 10^{12}	1.7 x 10^{12}	0.7 x 7.0 x 10^{11}	———	1.9 x 10^{13}	3 x 10^{12}	4.6 x 10^{12}**
1.0—3.0 x 10^{11}	2.0—5.0 x 10^{10}	0.1—3.0 x 10^{10}	———	1.0—4.0 x 10^{10}	0.2—2.0 x 10^{10}	3—6 x 10^{4}
6.4—6.6	7.0—7.7	8.1—12.6	7.9—11.0	10.0—10.2	9.7—11.1	7.2—7.0
5.6—5.8	5.2—6.0	6.7—6.9	6.3—7.3	5.3—6.1	6.6—7.5	6.9—7.9**
0.026—0.033	0.192	0.100—0.340	0.048—0.162	0.100	0.14—0.23	———
0.034—0.035	0.044—0.12	0.036—0.041	0.031—0.040	0.039—0.048	0.013—0.015	0.014—0.016
0.17—0.22	0.90—2.4	2.0—5.0	———	0.5—1.0	1.5—2.5	———
0.20—0.21	0.19—0.28	0.24—0.26	———	0.21—0.31	0.09—0.19	0.092**
70—106	90—120	122—128	121—123	120—180	180—186	180—186
0.15—0.19	0.15—0.25	0.15—0.23	———	0.12—0.22	0.14—0.22	———
0	0	0	———	0	———	———
V. Sl. attack	V. Sl. attack	0	———	V. Sl. attack	———	———
Sl. attack	Sl. attack	attack	———	Sl. attack	———	———
V. Sl. attack	V. Sl. attack	0	———	V. Sl. attack	———	———
Sl. attack	Sl. attack	attack	———	Sl. attack	———	———
attack	attack	attack	———	attack	———	———
attack	attack	0	———	attack	———	———
V. Sl. attack	V. Sl. attack	0	———	V. Sl. attack	———	———

** tests are ASTM unless otherwise noted. Conditioning procedures follow ASTM D-618-58T
A—40 hours at 23°C, 50% RH. /B—48 hours at 50°C, desiccation at RT. /C—96 hours at 35°C, 90% RH.

** mechanical and electrical properties for Cymel 3136 are determined according to Spec. MIL-M-14F.

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(THERMOSETTING) UREA-FORMALDEHYDE ALPHA CELLULOSE-FILLED MOLDING COMPOUNDS

Beetle molding compounds produce marproof, lustrous moldings highly resistant to detergents, oils and greases – they are supplied in powder or granular form and various plasticities to meet specific molding needs in compression molding.

BEETLE is formulated to meet these specifications: Federal L-P-406b, LC 726-1, ASTM D705-55, Grade 1 (Arc resistance limits are in process of revision by ASTM). Characteristics: unlimited range of lustrous colors, smooth, hard surface, odorless and tasteless, stain-resistant, wear-resistant, arc-resistant, track-resistant, good dielectric strength, durable. Applications: radio cabinets, stove hardware, wiring devices, electric appliance housings, cosmetic containers, closures, buttons.

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LAMINAC 4101 – medium viscosity, general purpose rigid resin developed for compression molding of reinforced trays, boxes, housings and similar products.

LAMINAC 4103 – medium reactivity, resilient resin – ideal for hot-press molding of products required to withstand heavy mechanical abuse – boats, auto bodies and truck cabs.

LAMINAC 4107 – high reactivity, medium viscosity resin – rigid and chemical resistant – suitable for fast high temperature molding as well as for other fabricating methods.

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LAMINAC 4111 – low viscosity, highly reactive resin – maximum chemical resistance and excellent electrical properties – for storage containers, electric and electronic parts.

LAMINAC 4116 – low reactive, general purpose resin – recommended for strength, rigidity and water resistance – for fishing rods, mannequins, radomes, castings (Laminac 4134 may be added for improved resilience).

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LAMINAC 4120 – fast curing, highly reactive, high viscosity resin – suitable for compounding with fillers and with color pastes for obtaining glossy resin rich surfaces.

LAMINAC 4123 – intermediate reactivity, general purpose resin – medium viscosity, useful in either high or low temperature applications for suitcases, chairs, safety helmets.

LAMINAC 4128 – low viscosity, highly reactive resin for hand lay-up or presswork – good hot strength – for aircraft accessories such as junction boxes, fuel tanks.

LAMINAC 4131 – fast curing, excellent moldability – intended for compounding with fillers and fiber reinforcement for premix molding compounds – good fiber-wetting – low density – molded parts have good hot strength and good resilience.

LAMINAC 4134 – low viscosity, flexible resin used in combination with rigid resins to improve impact and shock resistance.

LAMINAC 4146 – for production of self-extinguishing fibrous glass reinforced laminates and moldings – for motor housings under continuous heat, aircraft parts, hot air ducts.

LAMINAC 4151 – slightly thixotropic, low exotherm resin – for boat builders and other fabricators using hand lay-up techniques – non-sagging, excellent wet-out, fast curing.

LAMINAC 4152 – slightly thixotropic, low exotherm, excellent wet-out, fast curing – comparable in performance to Laminac 4151 but formulated specifically for use with resin-fiber depositor spray guns.

LAMINAC 4192 – for maximum resistance to discoloration on exposure to light – used for the production of flat or corrugated sheeting.

LAMINAC 4202 – high viscosity liquid resin – unusually long catalysed stability – odor free – cures at temperatures above 200°F – for large radomes and aircraft shelters.

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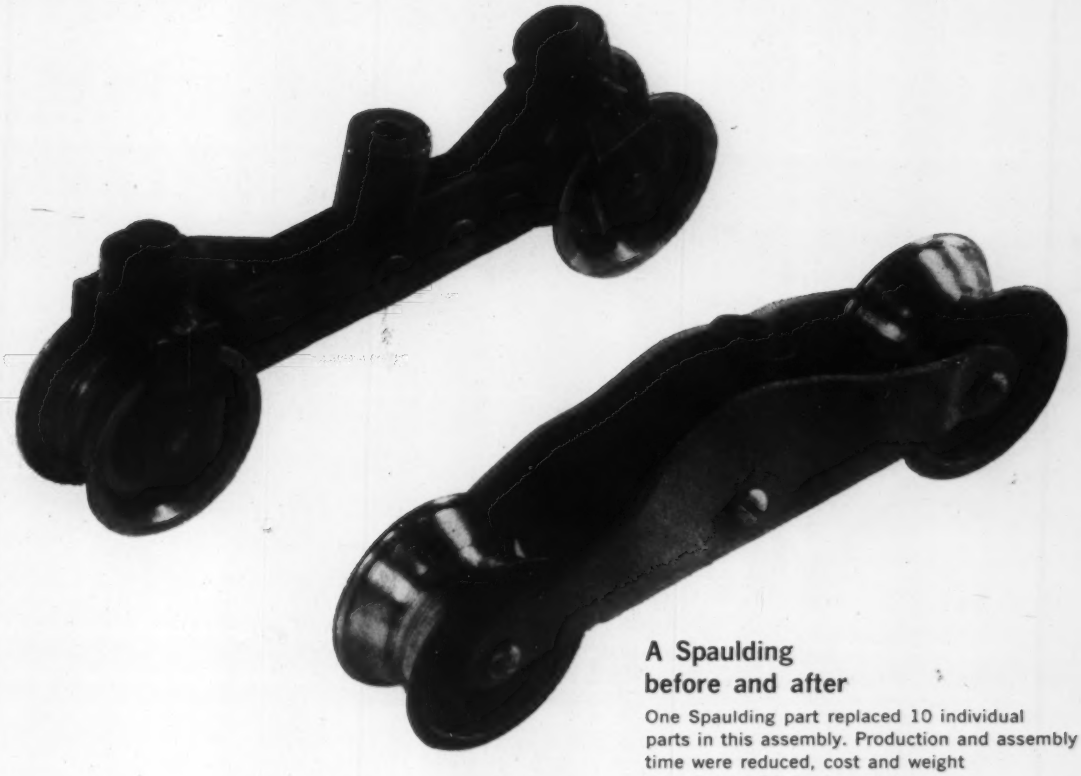

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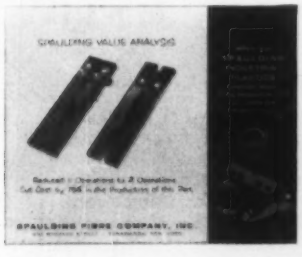

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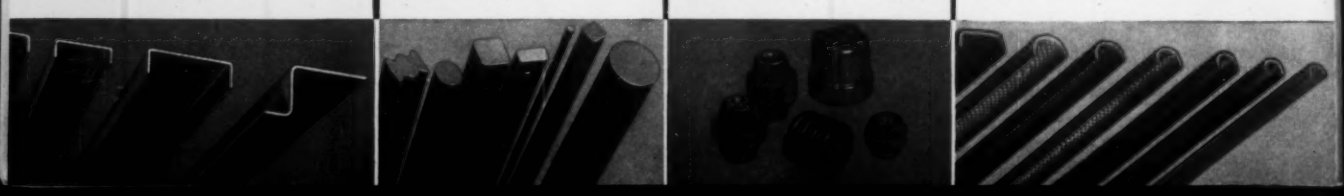
INSULATORS, in 13 low cost models with choice of thread sizes. Dimensional tolerances and impact strength superior to porcelain . . . moisture resistance and arc resistance greater than phenolic. Heights from 1⅜". UL-recognized flame retardance.

U-WEDGES, in 11 sizes, for retaining stator windings in motors. Much stronger and easier to drive than wood or fibre wedges, and space-saving design allows greater coil cross-section. Full Class B electrical insulation.



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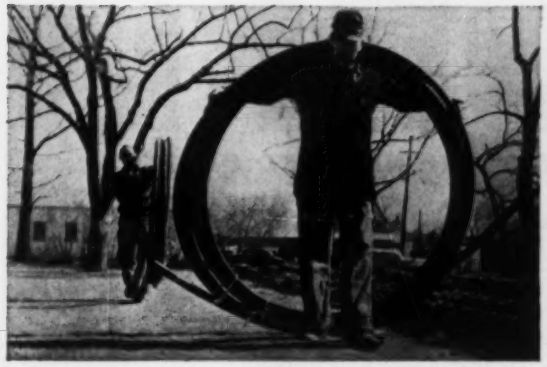
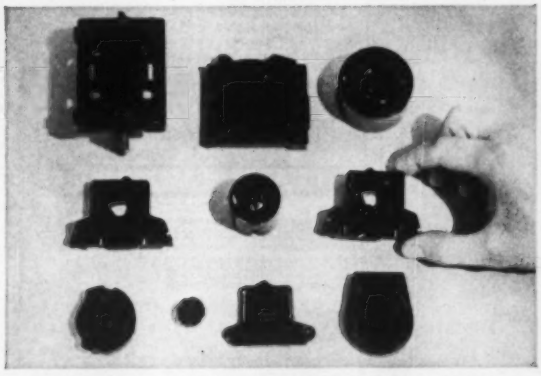
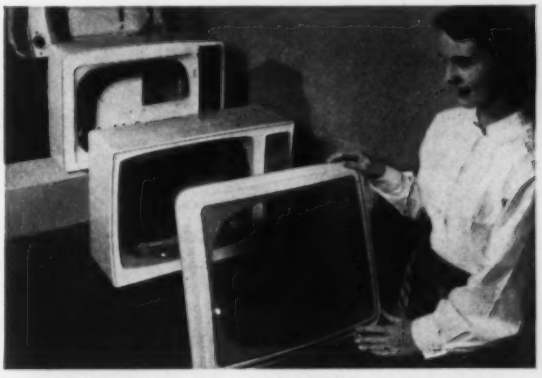


POLYETHYLENES: Light weight with strength. This 100 ft. coil of 2-in. polyethylene pipe is easily supported by one man. Flexible and rigid polyethylenes each have outstanding physical, chemical and electrical properties. Gas permeability and a broad range of colors make polyethylene film ideal for packaging.

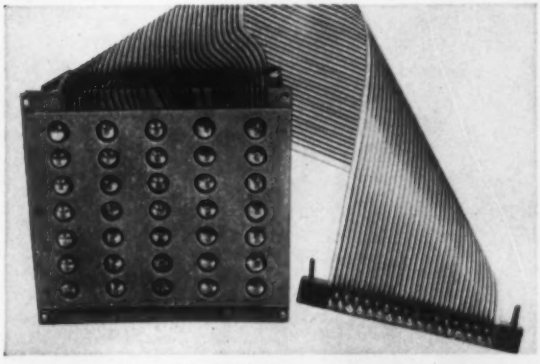
EPOXIES: With its coils embedded in epoxy, this motor is running under water. The strongest and hardest of plastics, epoxies are ideal for industrial coatings and reinforced laminations, including medium-to-long-run tools and dies. They are extremely tenacious when used as adhesives.



PHENOLICS: These electrical parts illustrate one of the long-time uses for phenolic plastics. Strong and durable, phenolics are also molded into washing machine agitators, furniture drawers, bottle caps . . . They are also excellent for chemical-resistant coatings and industrial or decorative laminates.



STYRENES: Television masks like these exhibit the superior eye-appeal of styrenes. A range of impact strengths, brilliant colors, and gleaming finish broaden the design applications of these materials. Molded and extruded, styrenes find use as refrigerator door liners, toys, packages, and housewares.



VINYLS: This flexible printed circuit has copper conductors laminated between layers of vinyl sheeting. Vinyls combine electrical resistance, formability, color, and elastomeric qualities. Tough, handsome vinyls can be fabricated into flexible or rigid film and sheeting. Inflatables, swimming pool liners, packaging, and wire insulation are important uses.

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BRAND REINFORCED PLASTIC

ROTATING STRESS LOADS are constantly changing on the modulus balancing cheek plate (indicated in blue) of this helicopter rotor by Kaman Aircraft. "SCOTCHPLY" is the only structural material tested that satisfied all requirements. Plies are oriented to meet the tension, bending and torsion strains developed in the blades.

Modulus of elasticity taken in the lengthwise direction and crosswise direction for several laminate orientations are shown below. Any intermediate ratios may be obtained as "SCOTCHPLY" can be tailored to meet specific stress requirements.

Cross-hatching indicates filament orientation

STRENGTH-TO-WEIGHT RATIO TOPS ALL STRUCTURAL MATERIALS

Strength/weight and other exclusive properties result from customized orientation of continuous, non-woven glass filaments*

What's the big difference between "SCOTCHPLY" and other pre-impregnated reinforced plastics? Only "SCOTCHPLY" BRAND Reinforced Plastic has continuous, non-woven glass filament* reinforcement.

Here are the superior properties that result:

★ ***UNMATCHED INDIVIDUAL PLY STRENGTH***—each ply consists of *continuous straight* filaments in parallel alignment, not crimped or woven.

★ ***HIGHEST DEGREE OF TAILORABILITY***—individual plies may be oriented to meet specific stress requirements; reinforcement (weight and bulk) is not wasted in directions or regions of low stress. This *degree* of tailorability is not possible with other reinforced plastics using woven cloth or short strand reinforcement.

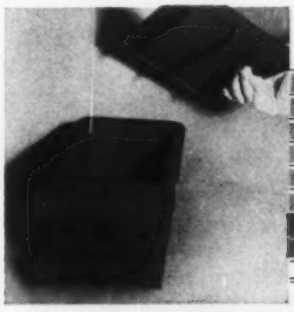
This duo of exclusive advantages combines to give "SCOTCHPLY" an unequalled strength-to-weight ratio and superior fatigue properties.

Sold in uncured rolls or sheets, "SCOTCHPLY" Reinforced Plastic is a moldable, laminated plastic consisting of a mechanically controlled ratio of resin to reinforcement*. Heat and low pressure in matched metal dies, vacuum or pressure-bag molding cure it into rigid form.

For complete information and technical service, write on your letterhead to Dept. XAB-110. Reinforced Plastics Division, 3M Co., 1210 University Ave., St. Paul 4, Minn.

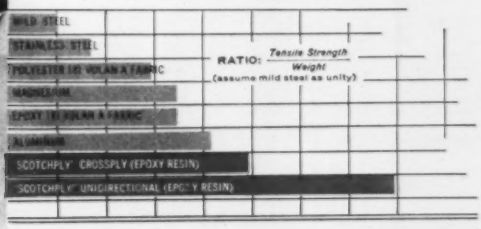
**Other available filaments: nylon, asbestos and other ablation materials. Epoxy, phenolic and other resin systems are available.*

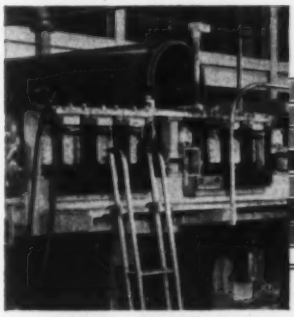
See Sweets Product Design File insert 2a. Mi



EXTREMELY HIGH TENSILE STRENGTH and light weight are essential in this battery case by Prewitt Aircraft for a classified missile. By proper orientation of reinforcing filaments, "SCOTCHPLY" provides maximum strength where strength is needed to withstand tremendous acceleration loads.

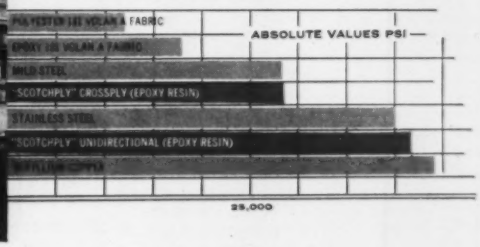
Tensile strength-weight ratios





FLEXURAL FATIGUE failure of metal Fourdrinier springs resulted in costly breakdowns on this paper machine manufactured by Rice Barton Corporation. Now Fourdrinier springs of "SCOTCHPLY"—tailored to the application—do the job.

Flexural-fatigue strength @ 2 x 10⁶ cycles



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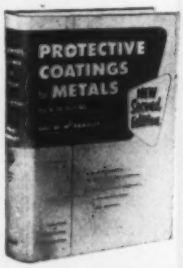

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Stretched Acrylic. Swedlow, Inc., Western Contracts Dept., 6 pp, illus., No. Y. General information, technical data, uses, and other information on stretched acrylic glazing material for high speed aircraft. **102**

High Temperature Laminates. Synthane Corp., 2 pp. General description, availability and properties of two high temperature industrial plastics laminates. **103**

Laminated Plastics Selection Guide. Taylor Fibre Co., 18 pp. Information on what laminates are, how they differ from other plastics, what materials are used, standard thicknesses and tolerances, and other data necessary for specifying and ordering high pressure plastics laminates. Included is a property chart on mechanical, electrical, and general purpose grades. **104**

Cellular Products. Toyad Corp. Series of technical bulletins and brochures give general descriptions, properties, characteristics, and typical uses of a line of flexible and rigid cellular products. **105**

Silicones for Shell Molding. Union Carbide Corp., Silicones Div., 4 pp, No. SF-1128. Properties of three silicone parting agents used in shell molding. **106**

Polystyrene Molding Compounds. Union Carbide Plastics Co., Div. of Union Carbide Corp., 16 pp, illus., Vol. 5, No. 1. Technical data and applications of four impact polystyrene molding compounds. **107**

Synthetic Rubber. Naugatuck Chemical Co., Div. of United States Rubber Co., 12 pp, No. 219. Compounding information, physical properties, oil and ozone resistance, and uses of a vinyl modified synthetic rubber called Paracril OZO. **108**

Mechanical Rubber Goods. Williams-Bowman Rubber Co., 6 pp, illus. Information on the services and facilities available for the production of mechanical rubber goods. **109**

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Material	General Description	Outstanding Properties	Fabricating Methods	Application Considerations
ELECTRICAL TRANSFORMER (AND MOTOR) INSULATION	Cellulose fiber materials produced in 60" x 120" sheets and in rolls, in gauges from .007" to 3".	Exceptionally pure, with uniform dielectric characteristics. Tough, homogeneous — long the standard insulating materials for transformers and motors.	Sheet sizes are standardized for assembly into transformers. Strips can be supplied or cut for blanking into small insulatiag parts. Rolls for automated operation.	Standard insulation for transformers, electric motors and other electrical equipment.
DUROID 100, 225, 700 SERIES	Fibrous insulating materials — U. L. recognized — produced in 60" x 66" sheets in gauges .031" to 3".	Arc resistance and dielectric strength equal to XP paper-base laminates. Retains dielectric strength under high humidity.	Parts can be formed or blanked on power presses, using steel rule or compound dies.	General purpose insulating materials. Used frequently in place of paper-base laminates where moisture pick up is not critical.
DUROID 800	Fibrous insulating material recognized by U. L. for sole support of current carrying parts. 60" x 66" sheets in gauges .031" to 3".	Rigid, springy material, with water absorption of less than 25% per 24-hour immersion. Excellent physical wet strength.	Flat punching, using compound or steel rule dies. Formable before curing.	Recommended for flat punched insulators as replacement for laminated phenolic.
DUROID 5600 SERIES	Teflon reinforced with ceramic fibers to form homogeneous sheet, rod or tube.	Electrical properties of Teflon but with much greater resistance to cold flow and heat distortion.	Blanking and punching on power presses, using steel rule or compound dies. Machined or molded parts.	Recommended for applications which require Teflon's electrical properties with improved resistance to heat and cold flow.
DUROID 5800 SERIES	Teflon reinforced by encapsulated glass micro fibers. Available as flat sheets, rods, tubes and copper-clad sheet.	Uniform electrical properties; lower coefficient of expansion than Teflon; no wicking effect. Copper-clad sheet has high bond strength.	Flat sheets readily punched. Rod and tube feature excellent machinability.	Primarily for high temperature dielectric use as circuit base stock, micro-wave strip or plumbing, missile antennae windows.
RX PHENOLIC MOLDING COMPOUNDS	Wide range of materials in medium to high impact grades. Uniform pellet size and rate of pour. Some formulations also in sheet form.	Low bulk factor, fast rate of cure. Combine impact strength with flexural strength. Clean, dust-free. Quality controlled for high-speed production.	Can be automatically preformed, compression or transfer molded on automatic equipment.	For high strength complex or simple components. (Grades can be supplied to meet special physical, molding or flame-resistant requirements.)
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CORROSION RESISTANCE:
6 MONTH TESTS OF CAST RESIN

Corrosive Agent (210°F.)	% retention of flexural strength		
	General Purpose Polyester	Isophthalic Resin	ATLAC 382
15% HCl	Failed	6%	64%
5% NaOH	Failed	Failed	60%
5% Hypochlorite	Failed	11%	59%
Water	9%	13%	79%

LITERATURE AVAILABLE

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Sheet materials
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1650°F

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Swedlow's silicone plastic laminates

650°F

Swedlow's X5G-138 and X5G-176 silicone base materials are available as flat sheeting or molded parts and offer protection up to 650°F.

Swedlow's X5G-138 provides maximum strength per unit of thickness and weight and is recommended for applications requiring flat sheets or simple contoured molded parts.

The X5G-176 laminate has slightly lower physical properties than X5G-138 but is recommended for applications requiring complex contours.

APPLICATIONS—Missile nose cones, exit cones, fins, stabilizers, adapter rings, closure rings, and similar uses. Applications in airstreams at missile speeds are possible.

Dyna-Therm 65—flexible flame-resistant coating

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A "major breakthrough"—insulation which can be applied easily in the field for protection of launching equipment from rocket flame and blast. It affords major dollar savings by protecting expensive cables and equipment through successive firings. It promises greatly reduced pad refurbishment time with resultant faster refire capability. It may be sprayed or applied with ordinary paint brush. Cures quickly at ambient temperatures. Intumesces under hot flame to develop full insulating capability, but remains flexible. Charred surface can be scraped away leaving undersurface ready for recoating. Field test indicates serviceability up to 6000°F.

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STABLE PHYSICAL PROPERTIES UNDER HIGH TEMPERATURES—Swedlow's X4G-116 is a high-temperature phenolic laminate that offers unusual physical stability at high temperatures up to 600° F. It is available in flat sheets, and can be molded to complex contours.

APPLICATIONS—Fins, stabilizers, missile nose cones, adapter rings, closure rings, and similar applications. May be used in airstreams at missile speeds.

450°F Swedlow's epoxy-plastic laminate

Swedlow's X6G-141 epoxy-plastic laminate gives the user an electrical insulating material resistant to fracture and warpage in installation, with characteristics of very low moisture absorption and high physical strengths over a prolonged temperature gradient. Approved under MIL-P-18177. Conforms to NEMA standards for type G-3 materials.

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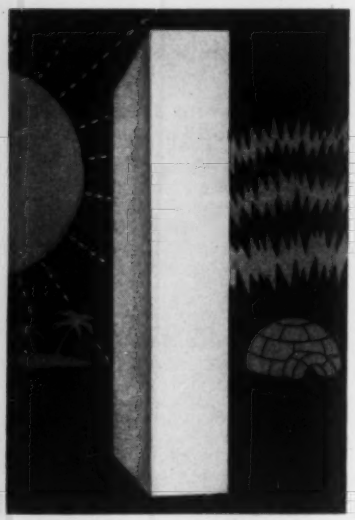
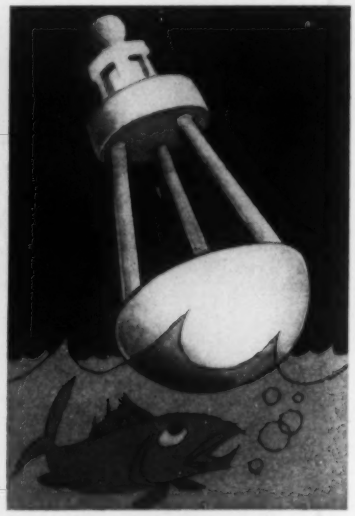
heat problems?

Five reasons why so many designers select



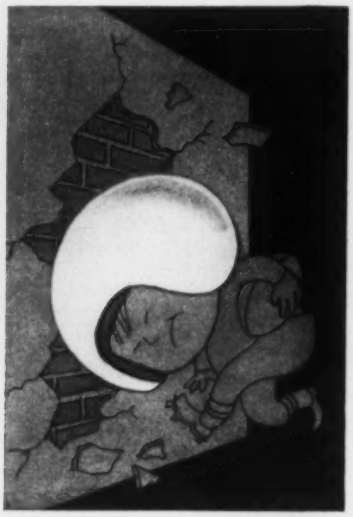
It's an insulator

The Thermal Conductivity (K Factor) of DYLITE is 0.242 at a 75°F. mean temperature at 2 lb./cu.ft. density. DYLITE resists heat, is unaffected by moisture condensate. Cooler chests molded of DYLITE keep food and beverages cold for days without ice refill. DYLITE is easily molded to fit contours of component parts of refrigerators, air conditioners and freezer cabinets.



It's waterproof

At 2 lb./cu.ft. density, DYLITE's rate of Water Vapor Transmission is 1.18 perms., and its rate of Water Absorption is 0.54 lbs./cu.ft. after 48 hrs. immersion. DYLITE is ideal for boats, rafts, buoys and other types of buoyant marine equipment. DYLITE remains in the water indefinitely without becoming water logged, and it is mildew-proof.



It's shock-resistant

DYLITE possesses an Energy Absorption ratio (Maximum Load) of 56.74 in. lbs./cu.in. at a density of 2 lb./cu.ft. For example, Royal electric typewriters are now shipped in shock-absorbent DYLITE packages—a result of performance tests in which DYLITE was proved superior to other materials for this job.

TYPICAL PROPERTIES OF DYLITE EXPANDABLE POLYSTYRENE—DENSITY 2 LB./CU.FT.

• Compressive Strength—30 Psi • Tensile Strength—55 Psi • Water Vapor Transmission—1.18 Perms.
• Water Absorption—0.54 Lbs./Cu.Ft. • Thermal Conductivity (K Factor)—0.242 at a 75°F. Mean Temperature
• Energy Absorption (Maximum Load)—56.74 In. Lbs./Cu. In.

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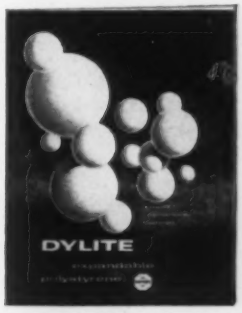
It's lightweight

DYLITE is lighter than cork—it can be molded in densities of 1 to 10 lb./cu.ft. The advantages of light weight are obvious. In packaging, DYLITE helps reduce shipping costs and makes handling easier. In the construction field, where DYLITE is used as an insulator, its light weight means fast and easy installation.

It's strong

DYLITE has a Compressive Strength of 30 psi and a Tensile Strength of 55 psi at a 2 lb./cu.ft. density. DYLITE can be used to great advantage in a wide variety of industrial design problems. For instance, sandwich structures that employ DYLITE as the core material offer high strength without sacrificing light weight.

... if you would like more information about versatile DYLITE expandable polystyrene, write for this free booklet.



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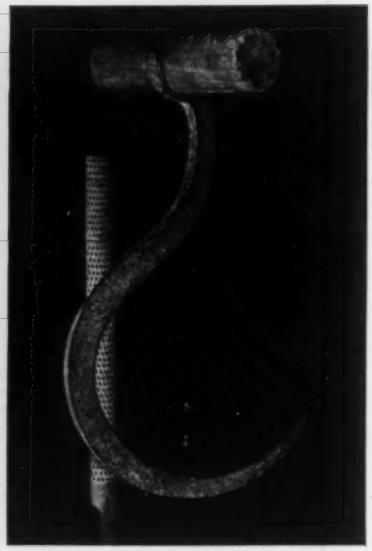


RESISTANCE TO TEAR AND ABRASION

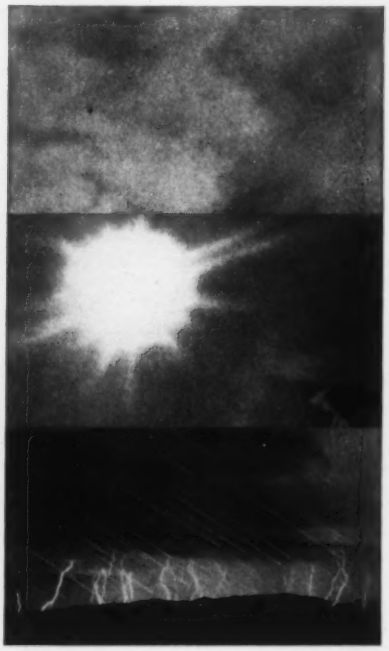
Enjay Butyl offers the highest aged tear strength of any rubber . . . even after long exposure to ozone and heat! Its inherent toughness resists abrasive wear, in such applications as tires, conveyer belts, hose and other mechanical goods.

RESISTANCE TO SUN-LIGHT AND WEATHERING

Enjay Butyl has proven its resistance to ultra-violet light, ozone, oxidation, moisture and mildew. Increases life of products such as weatherstrips, garden hose, wading pools and automotive parts.

RESISTANCE TO CHEMICALS

Enjay Butyl, because of its unique and extremely low degree of unsaturation, offers excellent resistance to corrosive chemicals. The preferred rubber for tank linings, hose, seals, gaskets and other applications where exacting chemical resistance is required.



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Enjay Butyl requires no additives for quality coloring over a wide range of hues. Famous for colorability and smooth finishes, Butyl has been successfully plastic coated for special applications.

RUBBER

PERFORMANCE

DAMPING PROPERTIES

Enjay Butyl absorbs shock and vibrational energy more completely than any other rubber. Resiliency can be varied in compounding and processing. Butyl is ideal for axle and body bumpers, motor mounts and sound-deadening applications.

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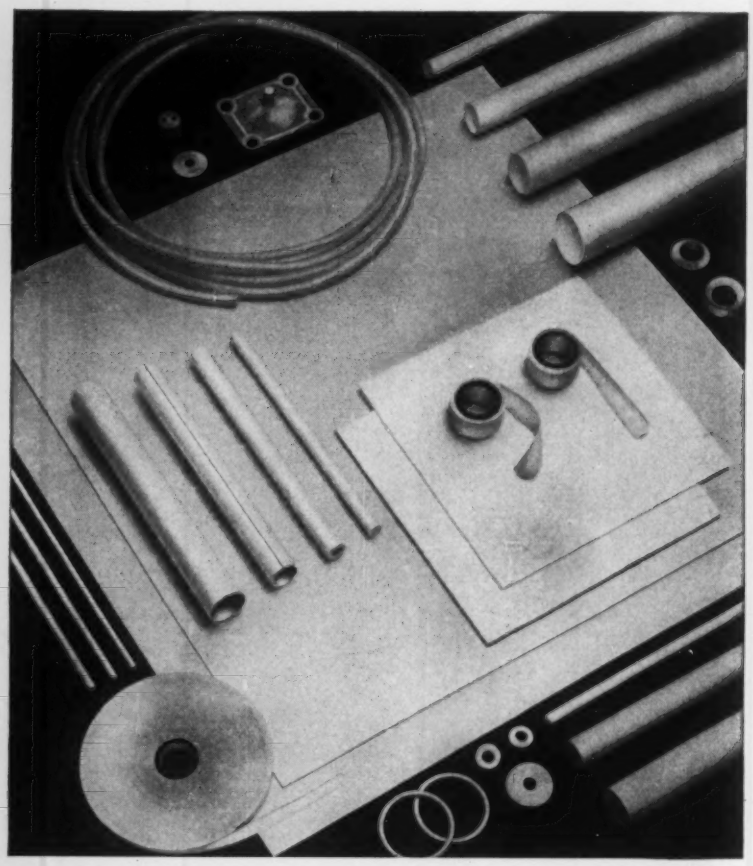

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POUNDS PER SQUARE INCH

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500°	——	21,900	49,000	18,300	——
600°	——	——	——	——	41,000
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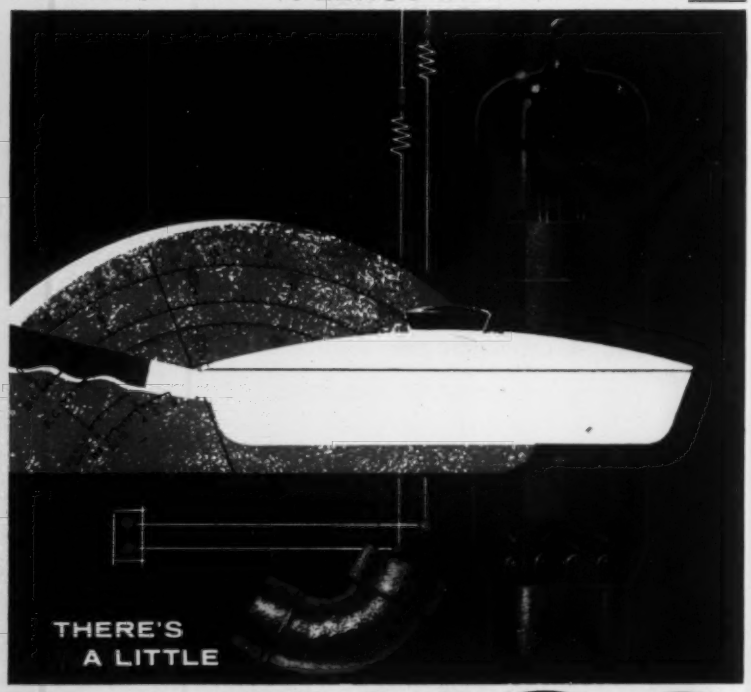

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PROPERTIES OF FORTIFLEX A60 AND B50

Properties related to Melt Index	Units	ASTM Method	PHYSICAL PROPERTIES A60-20	A60-70	A60-250	A60-500	A60-800	B50-20	B50-80 to B50-500
Melt Index	—	D1238-52T	0.2	0.7	2.5	5.0	8.0	0.2	0.8-5.0
Heat Distortion Temp., 66 psi	°F	D648-56	185	185	180	180	180	170-175	170-175
Impact Strength (1) Notched Izod (2)	ft. lb./ in. notch	D256-54T	23	18	13	3	0.7	7	5-1
Tensile Strength, 0.2 in./min. (3)	psi	D638-52T	3,700	3,500	3,300	3,300	3,300	3,200	3,100
Elongation, 0.2 in./min. (3)	%	D638-52T	28	25	18	13	13	30	25-18
Environmental Stress Cracking Resistance, F50 Value	hr.	Bell Lab. (4)	190	30	6	3	—	2,000	(5)
Properties not related to Melt Index									
Density	g/cc	D792-50	0.96	0.96	0.96	0.96	0.96	0.95	0.95
Highest Use Temperature (6)									
Continuous	°F	—	180	180	180	180	180	—	—
Intermittent	°F	—	225	225	225	225	225	—	—
Softening Temperature (7)	°F	—	260	260	260	260	260	255	255
Stiffness in Flexure	psi	D747-50	140000	140000	140000	140000	140000	100000	100000
Hardness	Rockwell R	D785-51	40	40	40	40	40	40	40
	Shore D	D676-49	65	65	65	65	65	64	64
Mold Shrinkage (8)									
Length	in./in.	—	.010-.030	.010-.030	.010-.030	.010-.030	.010-.030	.010-.030	.010-.030
Width	in./in.	—	.010-.025	.010-.025	.010-.025	.010-.025	.010-.025	.010-.025	.010-.025
Flammability	in./min.	D635-44	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Water Absorption 24 hr. at 77°F	% gain	D570-54T	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Refractive Index	n_{D}^{25}	D542-50	1.54	1.54	1.54	1.54	1.54	1.54	1.54

ELECTRICAL PROPERTIES

	Units	ASTM Method	Frequency (Cycles per Second)	Value
Dielectric Strength (Short time)	volts/mil	D149-55T	—	500
Volume Resistivity	ohm cm.	D257-54T	—	$6x10^{15}$
Dielectric Constant	—	D150-54T	$1x10^{3}$	2.35
			$1x10^{6}$	2.36
Dissipation Factor	—	D150-54T	$1x10^{3}$	0.0002
			$1x10^{6}$	0.0003
Loss Factor	—	D150-54T	$1x10^{3}$	0.0007
			$1x10^{6}$	0.0007

TYPICAL CHEMICAL RESISTANCE

	Value*
Acetic Acid, glacial	0.7
Sulfuric Acid 98%	0.0
Sodium Hydroxide 50%	0.0
Ammonium Hydroxide 28%	0.0
Carbon Tetrachloride	14.0
Methyl "Carbitol"	0.1
Water	0.0
Gasoline	6.0

*% Increase in wt. after 30 days immersion at 80°F. Sample specimens were 1" x ¼" x ⅛".

FOOTNOTES

(1) Impact values observed on injection molded bars should not be considered indicative of practical impact values for molded items where other factors affect the impact value. While its impact value will be sufficient for most uses, Fortiflex B should be evaluated for each specific application.

(2) Injection molded specimens, ⅛" x ½" cross section, notch in the ⅛" face. A60-20, A60-70 and A60-250 specimens did not break. A60-500 and Fortiflex B50 copolymers exhibited partial or hinged breaks.

(3) Injection molded Type 1 specimens, ⅛" thick. Tensile strength and elongation data recorded at the first yield point.

(4) ASTM Standard on Plastics, Issue of February, 1957. Appendix, Page 831—Proposed Method of Test for Environmental Stress Cracking of Ethylene Plastics.

(5) Fortiflex B50-80 has an environmental stress cracking resistance F_{50} value of 160 hrs.

(6) Highest use temperature depends on part design, molding and service conditions, special formulations are available for continuous use at higher temperatures up to 212°F.

(7) Method of Karrer et al, Ind. Engr. Chem., Anal. Ed. 2, 96 (1930).

(8) Mold shrinkage depends on part design and molding conditions.

COMPOUNDS AND RESINS...

INDUSTRIAL PRODUCTS...HOUSEWARES...TOYS...PACKAGES

FORTIFLEX A ... linear polyolefins

Fortiflex A is available in both natural and colored molding powders. Five formulations provide a wide flow range.

A60-20 possesses the highest impact strength, stress cracking resistance and low-temperature strength of the A series, and requires somewhat higher process temperatures. It's recommended for extrusion, calendering, blow molding or injection molding of very small parts requiring maximum physical properties.

A60-70 is a general-purpose resin. It's recommended for injection molding of small parts with limited surface area; for extrusion, calendering, blow molding, and as a rubber compounding additive.

A60-250 is suggested for intermediate-sized injection molded articles where better moldability and improved surface finish are required.

A60-500 possesses the best moldability for large-area moldings and applications where maximum processability and high surface gloss are required.

A60-800 is used primarily as a blending component with Fortiflex D polyethylene. It offers substantially improved flow characteristics with reduced impact strength compared to other resins in the Fortiflex A series. It can be used in blends, single-use containers, or items requiring low impact strength such as certain toys and novelties. It is not recommended where stress cracking is a problem.

TYPICAL APPLICATIONS: housewares, appliance, electrical and automotive parts, filaments for textiles and rope, bottles and containers, toys, industrial parts and protective helmets.

FLAME RESISTANT FORTIFLEX. Celanese offers specially formulated flame resistant variations of Fortiflex A60-70, A60-250, and A60-500. These formulations are opaque, self-extinguishing, high-density polyethylenes with a specific gravity of 1.04. Their stiffness, hardness and tensile strength are approximately the same as the standard resins', although heat distortion values under 66 psi are slightly lower and impact strength is somewhat reduced. Burning rate or flammability is reduced to the point where they can be classified as non-burning materials under ASTM D-635-44.

FORTIFLEX B ... linear copolymers

The Fortiflex B series offers a family of resins with an extremely broad range of properties and special advantages. They make it possible to upgrade many applications now employing other thermoplastics, and open up many new fields of application for plastics.

Fortiflex B is an excellent injection molding plastic and provides outstanding stress crack resistance. Processability of Fortiflex B resins is somewhat improved over the Fortiflex A series resins when compared on a melt index for melt index basis. Thus, cycle time for a given part may be less for these resins compared to Fortiflex A, since their cold point and viscosity are lower.

In tests under a static load, properly oriented filaments of the new polymer show reduced tendency to stretch.

APPLICATIONS: filaments for rope and outdoor furniture webbing, wire covering, blown bottles and containers, and pipe.

Applications for injection molding include: containers for stress-active agents, drum plugs, fittings and couplings, thin-walled moldings, large area moldings, insert moldings, bottle caps and closures.

The Fortiflex B series has opened new prospects for the blow molding of bottles and hollow-ware.

FORTIFLEX C ... medium density polyethylenes

Fortiflex C is a medium density resin presently offered only in a .934 density and 1.7 melt index. It is midway in stiffness between the softer type low density polyethylenes and the rigid type Fortiflex A and B resins. Fortiflex C is available in three different formulations for film, paper coating and pipe extrusion.

The film formulation is ideal for the extrusion of film for overwraps for stationery and bread and provides excellent clarity in chill roll extrusion. The paper coating formulation gives optimum greaseproofness at ¾ mil thickness, and it passes MIL-B-121B at 12 pounds per ream. The pipe formulation is sold only in black. It is NSF approved, meets the proposed 1960 revision of CS-197 Type II pipe, and has a compounded density of .942.

FORTIFLEX D ... low density polyethylenes

The Fortiflex D series of polyethylene resins is available in a range of densities from .915 to .924 and in a variety of melt indices which provide a line of resins ideal for injection and blow molding as well as the extrusion of film, pipe, wire covering and paper coating. These resins range from moderately stiff materials at the top of the density range to the softest low density polyethylenes commonly in use today.

Within this line of resins are materials specially suited to large, medium and small area injection molded toys, housewares, closures and industrial parts; coatings for locker wrapping paper, milk cartons, laminating to aluminum foil and acetate, multi-wall bags, kraft and cellophane. Also available are resins for NSF pipe that meet the proposed 1960 revision of CS-197 Type I, wire coverings for tree and line wire and power cable as well as cable jacketing and primary insulation which meet ASTM D1248-58T, Type I, Grade 4 and Federal Specifications LP-590, Type I, Grade 7. Film resins include materials for blown or chill roll film for freezer bags, produce bags, garment bags, soft goods overwraps, and general purpose films. Blow molding resins cover both general purpose requirements in squeeze bottles and critical packages where superior stress cracking resistance is required.

Celanese CELLULOSICS AND POLYESTERS

FORTICEL ... cellulose propionate

Its excellent *balance* of desirable properties makes Forticel distinctive among thermoplastics. Its combination of toughness and good flexural strength is unique among cellulose ester plastics. And it is free of objectionable odor. The high impact strengths of Forticel occur at moderate plasticizer levels, where its other fine characteristics, such as dimensional stability and stiffness are also optimum. No other cellulose plastic of similar general properties has less humidity expansion. Its low water absorption results in stability against warpage. And Forticel has considerably more resistance to weathering than cellulose acetate, and is very similar to cellulose acetate butyrate in this respect.

Forticel provides an exceptional luster on molded surfaces, obtainable on a fast cycle—in some items the fastest of all the cellulosics. A free flowing plastic, it can be injection molded with great ease, and lends itself to restricted gating and complicated mold layouts. Its superior flow insures practically invisible weld lines where two streams of plastic meet in the die. Forticel eliminates problems of flow around mold pins. Forticel is produced in four series of formulas offering different flow ranges and end-use advantages. It is offered in a range of transparent, translucent and opaque colors.

TYPICAL APPLICATIONS: pens, telephone housings, automotive parts, personal items, business machine keys, vacuum cleaner attachments, handles, small equipment housings.

ACETATE ... molding compounds

Economical, versatile Celanese Acetate is a widely used cellulosic plastic. In toughness, acetate can seldom be matched by any other plastic in its price bracket. It has high impact strength, rigidity, a hard surface, satisfactory dimensional stability for a wide range of applications. What's more, acetate is free of objectionable odor and has relatively good temperature stability. The XK series is formulated entirely of ingredients considered acceptable for use in contact with foods by the Food & Drug Administration. Dielectric properties are good. The plastic is unharmed by common hydrocarbons such as gasoline, benzene and oils.

Acetate has excellent moldability, and molding temperatures are not critical. The plastic is free-flowing, which minimize the problem of weld lines, and is recommended for applications incorporating metal inserts. With the aid of pre-plasticizing machines, heavy parts can be molded in one cavity, or family molds can be used. Acetate molds with an excellent surface finish, and it is easily fabricated. Parts may be cemented together to give a bond as strong as the original pieces. Formulations can be widely varied in properties by use of various types and amounts of plasticizers.

Acetate is produced in a number of formulations—including flame resistant material in a broad range of flows. It is offered in a practically limitless variety of transparent, translucent and opaque colors, as well as crystal clear. The flame resistant XFA and XFB formulations have achieved wide acceptance in the molding of appliance parts and housings where Underwriters approval may be a problem.

TYPICAL APPLICATIONS: toys, shoe heels, appliance housings, toilet seats, jewelry, tool handles, sun glasses, brush backs.

CELANESE POLYESTER RESINS ... for boats ... auto and truck bodies ... housings ... tanks and tank linings ...

Celanese polyester resins are thermosetting liquids: 100 percent polymerizable which do not liberate volatile by-products during cure. The Marco series of base resins are available in blends with styrene, vinyl toluene, methyl methacrylate or diallyl phthalate monomers in a range of varying viscosities. These resins can be readily cured at elevated temperatures employing peroxide type catalysts at moderate to contact pressure. With the addition of accelerators, it is possible to affect rapid cure at room temperature thus eliminating the need for heating equipment.

The simple fabricating techniques required to use Celanese polester resins, combined with the outstanding properties of the end products, such as high strength, light weight, resistance to moisture, excellent weathering, and chemical resistance have led to their use in the production of a broad range of items in the industrial, construction, transportation and decorative fields. Included are such products as auto bodies, aircraft parts, boats, buttons, corrugated and flat sheeting, ducting, fishing rods, furniture, housings, shelters, tanks, trays, tote boxes, trophies and many others.

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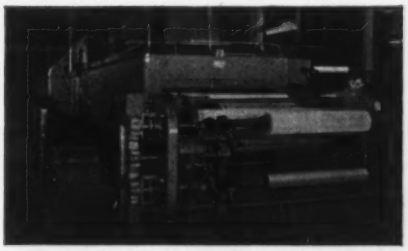

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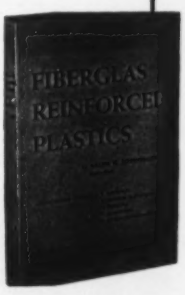

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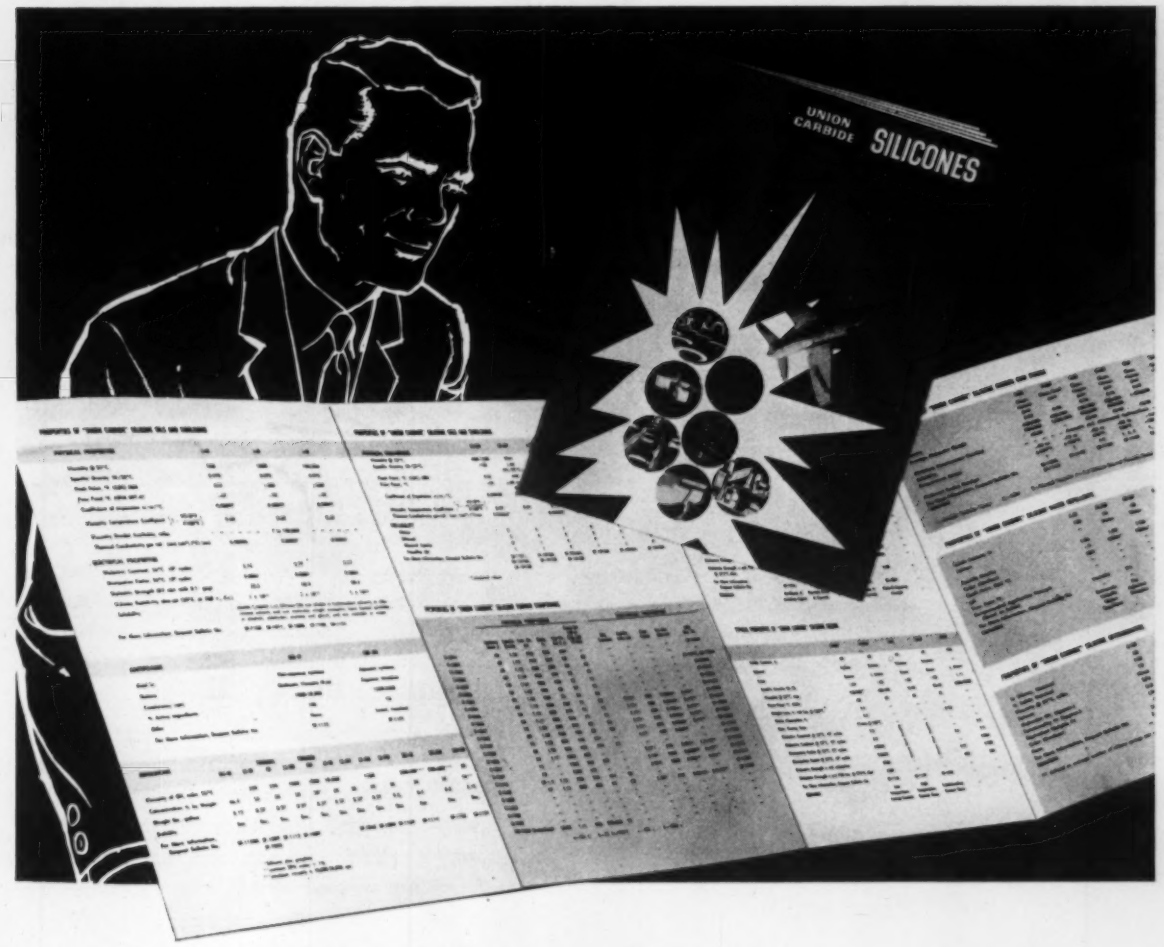

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Properties		502	506	6005	6010	6020
	epoxy content					
	1. epoxy value (eq./100 g.)	0.40-0.43	0.54-0.58	0.53-0.55	0.51-0.54	0.48-0.51
	2. weight per epoxide (WPE)	232-250	172-185	182-189	185-196	196-208
	epoxide equivalent (ev.)	—	—	—	—	—
	weight per gallon (lb.)	9.3-9.6	9.3-9.6	9.6-9.8	9.6-9.8	9.6-9.8
	color (Gardner)	3 (max.) **	3 (max.)	3 (max.)	3 (max.)	3 (max.)
	melting point (Durrans) °C.	(liquid)	(liquid)	(liquid)	(liquid)	(liquid)
	viscosity (at 25°C.) Brookfield (cps.)	2100-3600	500-700	7000-10000	12000-16000	16000-20
	Gardner-Holdt	—	—	—	—	—
Structural	adhesives					
	body "solders"					
	casting					
	caulking and sealants					
	electrical					
	impregnating					
	laminating					
	tooling					
Coatings	maintenance: equipment finishes					
	marine finishes					
	masonry finishes					
	structural steel coatings					
	tank coatings					
	product finishing: aircraft finishes					
	appliance primers					
	automotive primers					
	can & drum linings					
	chemical-resistant finishes					
	collapsible-tube coatings					
	furniture finishes					
	metal decorating finishes					
	pipe & tank linings					
	trade sales: concrete floor paints					
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196-222	232-278	385-500	425-550	875-1025	2000-2500	2500-4000	450-530	550-700	1650-2000	143 (av.)	133 (av.)
–	–	–	145 (av.)	175 (av.)	200 (av.)	–	155 (av.)	170 (av.)	–	–	–
9.6-9.8	9.6-9.9	9.9 (av.)	9.9 (av.)	9.9 (av.)	9.8 (av.)	9.8 (av.)	9.9 (av.)	9.9 (av.)	9.8 (av.)	7.5 (av.)	9.2 (av.)
5 (max.)	5 (max.)†	4 (max.)†	4 (max.)†	4 (max.)†	5 (max.)†	5 (max.)†	4 (max.)†	4 (max.)†	4 (max.)†	<1	5 (max.)
(liquid)		60-75	65-75	95-105	125-135	145-155	65-75	75-85	113-123	(liquid)	(liquid)
25000-32000	–	–	–	–	–	–	–	–	–	3	19
–	Z4-Z6**	–	D-G†	R-U†	Z-Z2†	Z2-Z5†	D-G†	G-K†	X-Z†	–	–

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viscosity (G.H.)	Z3-Z5	X-Z	Z3-Z5	Z4-Z6	Y-Z2	Z5-Z7	W-Z	Z1-Z4	Z2-Z4	Z1-Z4
Room Temperature Systems:										
maintenance, marine and floor finishes										
specialty maintenance										
Baking Finishes:										
product finishes, primers, can and drum linings										

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(This above section occupies pages 36 through 296)

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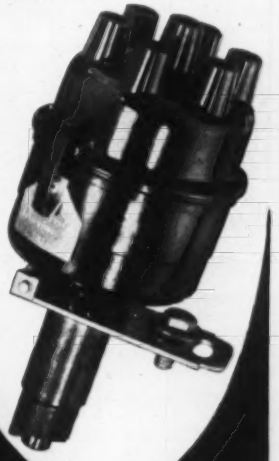

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	GRADE		TYPE OF MATERIAL		
NELCO	NEMA	MIL	RESIN	BASE	SALIENT CHARACTERISTICS
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101/102	—	—	Epoxy	Glass Fabric	Superior Flushing Grade; Meets MIL Specs
105	—	GF	Epoxy	Glass Fabric	Flame-Retardant; Good Electricals
110	G-11	GB	Epoxy	Glass Fabric	High Temperature; Flame-Retardant
130	FR-2	PE	Epoxy	Paper	Good Electricals; Suitable for Flushing
135	FR-3	PE	Epoxy	Paper	Flame-Retardant; Punchable; Dimensionally Stable
220	XXP	—	Phenolic	Paper	Good Electrical & Mechanical Characteristics
230	XXXP	PP	Phenolic	Paper	Gold-Punching to 3/32"; High Electricals
230-R	XXXP	PP	Phenolic	Glass-Reinforced Paper	Extremely High Impact and Flexural Strengths

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SUPPLIERS' LITERATURE

Nonmetallics
(except Plastics and Rubber)

Properties of Wool Felts. American Felt Co., 8 pp, No. 8-60. Lists comparative chemical, physical and mechanical properties of 36 grades of wool felt used for mechanical and industrial applications. Includes information on available forms and fabricating methods. **111**

Properties of Ceramics. American Lava Corp., Steatite Div., 8 pp, No. 591. Physical, mechanical and electrical properties of steatite, forsterite, cordierite, lava, alumina and magnesium silicate ceramics. Also gives properties of silicon carbide and zirconium oxide. **112**

Chrysotile Asbestos. Lake Asbestos Div., American Smelting & Refining Co., Inc. Advantages, characteristics, properties and applications of chrysotile asbestos. **113**

Cellophane Film. American Viscose Corp., Film Div., 24 pp, illus. Characteristics, uses and dimensions of cellophane film. **114**

High Temperature Materials. Carborundum Co., Advanced Materials Technology, 8 pp, illus. Properties, uses and general information on 26 materials designed to resist abrasion, corrosion, nuclear radiation and high temperatures. Included are various metals and alloys, and several carbides, nitrides and oxides. **115**

Felt. Continental Felt Co. Information on wool, synthetic fiber and colored felts. **116**

Industrial Ceramics. Coors Porcelain Co., 4 pp, illus. Series of case histories describe advantages of ceramics for several different applications. Included is a chart giving mechanical and electrical properties of five grades of alumina ceramics. **117**

Glass Radiant Heaters. Corning Glass Works, 14 pp, illus., No. Te-70. General description, installation information, maintenance instructions, advantages, characteristics, and typical applications of tubular and panel heaters made of glass. **118**

Silicones. Dow Corning Corp., 16 pp, illus., No. 1-115. Forms, properties and applications of silicones used as adhesives, release agents, laminating resins, rubber compounds, electrical insulation, etc. **119**

Vinyl-Coated Fabrics. E. I. du Pont de Nemours & Co., Inc., Fabrics Div., Nos. AIA 28-F, AIA 28-C. General information, specifications, advantages, methods of application, materials used, and other information on vinyl-coated fabrics. Included are several dozen samples of various colors and textures available. **120**

Fused Quartz. Amersil Quartz Div., Engelhard Industries Inc. Characteristics, properties, advantages, and typical applications of fused quartz. **121**

Felt in Electric Motors. Felters Co., 9 pp, illus, No. SE-9-512. Characteristics, advantages, typical applications, properties, and treatments of felts and synthetic nonwoven fabrics used for mechanical parts in electrical motors. **122**

Glass Reinforcement for Plastics. Ferro Corp. Advantages, characteristics, and uses of glass cloth, fiber, filaments, etc., for plastics' reinforcement. **123**

High Temperature Insulation. Fiberite Corp., 16 pp, illus. Characteristics, properties, molding techniques and uses of a line of variously reinforced plastic compounds for high temperature insulation. **124**

Wood Products. Gamble Brothers, Inc., 28 pp, illus. Shows wood products manufactured by the company, including industrial wood parts, chair parts and athletic apparatus. **125**

Graphite. Graphite Specialties Corp., 4 pp, No. GS-101-1. Chemical and physical properties of an impervious graphite for high temperature parts. **126**

Thermal Insulation. Johns-Manville Sales Corp., 54 pp, illus., No. IN-244-A. General description, typical applications, available forms and types, advantages, and specifications of a line of thermal insulation materials. **127**

Cemented Carbides. Kennametal, Inc., 24 pp, illus., No. B-666. Outstanding properties and typical uses of tungsten, titanium, tantalum, columbium and cobalt cemented carbides. **128**

Specialty Papers. Knowlton Bros., Inc., 12 pp, illus. Information on technical and industrial specialty papers. Shows company research and manufacturing facilities. **129**

Engineered Glass Parts. Kopp Glass Inc., 20 pp, No. 760. Services and facilities available for the production of colored and clear glass parts. Included are examples of sizes, colors, designs and custom-engineered glass products. **130**

Glass Products. Lancaster Glass Corp., 28 pp, illus. Case histories on the use of glass in television tubes, auto dome lights, desk sets, refrigerator lights and vending machines. **131**

Industrial Ceramics. McDanel Refractory Porcelain Co., 4 pp, illus. Briefly describes ceramic pump pistons, combustion tubes, heat reflectors, crucibles and liners. **132**

Paper Products. Mosinee Paper Mills Co., 3 pp, illus. Outlines uses and advantages of a flame resistant paper and average physical properties of flat and creped neutral papers. **133**

Glass-Bonded Mica. Mycalex Corp. of America, 24 pp, illus. Physical, electrical and thermal properties, and dimensional tolerances of ceramoplastics and glass-bonded micas. **134**

Carbon and Graphite. Ohio Carbon Co., 8 pp, illus., No. 1164A. Composition, characteristics, properties and applications of carbon and graphite. **135**

Glass Fiber Insulation. Pittsburgh Plate Glass Co., Fiber Glass Div., 4 pp, illus. Advantages of using glass fibers for sound and heat insulation applications. **136**

Carbon Graphite. Pure Carbon Co., Inc., 12 pp, illus., No. 55. Catalog on carbon graphite for mechanical applications. **137**

Coated Fabrics. Reeves Bros., Inc., 4 pp, illus., No. 107B. Physical properties, dimensions and uses of a neoprene rubber-coated nylon **139**

Carbon and Graphite. Speer Carbon Co., 8 pp, illus. General advantages, properties, available grades and other information on a line of carbon and graphite products. **140**

Carbon and Graphite. Stackpole Carbon Co., 54 pp, illus., No. 40 C. Properties, and mechanical, chemical, electrical and refractory uses of carbon and graphite. **141**

Thermal Insulation. H. I. Thompson Fiber Glass Co., chart. Information on thermal insulations for temperatures from —300 F to 3000 F. **143**

Synthetic Fiber Felt. Troy Blanket Mills, 8 pp, illus. Strength, dimensional stability and chemical resistance of a synthetic non-woven material called Troyfelt. **144**

Carbon, Graphite Products. National Carbon Co., Div. of Union Carbide Corp., 4 pp, illus., No. 5008. Dimensions and characteristics of carbon, graphite, and impervious carbon and graphite equipment for chemical processing applications. **145**

Sintered Metallic Oxides. U. S. Stoneware Co., Alite Div., 8 pp, illus., No. A-7R. Electrical characteristics, size limitations, dimensional tolerances, chemical and heat resistance, and physical properties of sintered metallic oxides. **146**

Cemented Carbides. Vascoloy-Ramet Corp., 4 pp, No. 5803. General characteristics, hardness, rupture strength, density and applications of cemented carbides. **147**

Graphite. Wickes Corp., U. S. Graphite Co. Div., 8 pp, No. G-12. Properties, applications, and other data on graphite. **148**

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PROPERTIES OF MATERIALS

Other Nonmetallics

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Mechanical and Electrical Ceramics—Fired Parts

Type →	Polycrystalline Glass (Pyroceram) 9606	Polycrystalline Glass (Pyroceram) 9608	Cordierite	Forsterite
PHYSICAL PROPERTIES				
Specific Gravity	2.60	2.50	2.29–2.65	2.9
Ther Cond, Btu/hr/sq ft/°F/ft	2.10	1.14	0.97–2.40	1.94–2.40
Coef of Ther Exp, per °F				
68–212 F	4.0×10^{-6}	$0.22–1.1 \times 10^{-6}$	2.08×10^{-6}	4.72×10^{-6}
68–570 F	3.16×10^{-6}	$0.22–1.1 \times 10^{-6}$	—	—
68–932 F	2.7×10^{-6}	$0.4–1.1 \times 10^{-6}$	1.68×10^{-6}	5.40×10^{-6}
Thermal Shock Resistance	Good	Good	Good	Moderate
Water Absorption, %	0.00	0.00	0.02–3.2	0.00–0.02
Gas Permeability	Gas-tight	Gas-tight	—	Gas-tight
Specific Heat, Btu/lb/°F	0.185	0.190	—	—
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	17.3×10^6	12.5×10^6	7×10^6	—
Mod of Rupture, 1000 psi	20	16–23	6.8	19
Tensile Strength, 1000 psi	—	—	3.0	10
Hardness (Knoop)	698[d]	703[d]	7	7.5
Impact Strength (Charpy), in.-lb				
¼ In. Dia	—	—	7.4	7.5
½ In. Dia	—	—	4.4	2.4–4.0
Compressive Strength, 1000 psi	—	—	52–95	80–85
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm-cm				
68–77 F	2×10^{16}[b]	6.3×10^{12}[b]	$>10^{14}$	$>10^{14}$
212 F	1.6×10^{8}	1.3×10^{11}	—	5.0×10^{13}
482 F	10^{10}	1.26×10^{8}	—	—
572 F	2×10^{8}	2×10^{7}	—	7.0×10^{11}
662 F	5×10^{8}	6.31×10^{6}	—	—
932 F	2×10^{7}	3.1×10^{8}	—	1.2×10^{10}
1292 F	—	—	—	1.0×10^{8}
1652 F	—	—	—	3.0×10^{6}
Dielectric Strength, v/mil	250–350	—	140–230	250
Dielectric Constant				
60 Cycles	5.62[c]	7.13[c]	—	6.3
1 Mc	5.58	6.78	4.02–6.23	6.2–6.5
100 Mc	5.52	6.55	—	6.1
10,000 Mc	5.45	—	—	5.8
Dissipation Factor				
60 Cycles	0.0016[c]	0.020[c]	—	0.0014
1 Mc	0.0015	0.0030	0.0010–0.00930	0.0002–0.0004
100 Mc	—	—	—	0.0003
10,000 Mc	0.00033	0.0068	—	0.0010
Loss Factor				
60 Cycles	0.009[c]	0.14[c]	—	0.009
1 Mc	0.009	0.026	0.0297–0.0579	0.001–0.002
100 Mc	—	—	—	0.002
10,000 Mc	0.002	0.045	—	0.0058
Te Value, F[e]	1400[b]	815[b]	1436	680–>1832
Temp Coef of Capacitance Chg[f]	—	—	420	—
HEAT RESISTANCE				
Max Rec Svc Temp, F	—	—	—	1832
USES	Developed for uniform electrical properties in missile radomes; suitable for high temperature, high frequency applications in electronics	General purpose; line of heatproof cooking-serving ware; telescope mirror blanks	Aircraft firewall connectors, appliance coil supports and terminal blocks, automotive heater cores, hot point insulators, brazing fixture parts, foundry parts, fuel burner tips, thermostat controls	Very low loss insulators, ceramic-to-metal seals (close tolerances obtainable by grinding)

[a] Alumina properties are on "Refractories" pages. [b] Extrapolated. [c] 100 cycles. [d] Knoop hardness at 100 gm.
[e] Te value is the temperature at which a cubic centimeter of the material has a resistance of 1 megohm. [f] 77–185 F, parts per million.

Mechanical and Electrical Ceramics—Fired Parts

Type →	Standard Electrical	Steatite	Zircon
PHYSICAL PROPERTIES			
Specific Gravity	2.37–2.53	2.5–2.92	3.43–3.86
Ther Cond, Btu/hr/sq ft/°F/ft	0.87–1.57	1.45–1.94	2.88–3.61
Coef of Ther Exp, per °F			
68–212 F	2.00×10^{-6}	$3.33–3.99 \times 10^{-6}$	$1.31–1.84 \times 10^{-6}$
68–932 F	2.70×10^{-6}	$4.52–5.50 \times 10^{-6}$	$2.09–2.16 \times 10^{-6}$
Thermal Shock Resistance	Fair	Moderate	Good
Water Absorption, %	0.0–0.1	0.0–1.0	0.0–9.0
Gas Permeability	Gas-tight	—	—
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	10×10^6	$13–16 \times 10^6$	21×10^6
Tensile Strength, 1000 psi	2.5–7.0	4.8–15	4.5–12
Hardness (Mohs)	7.0–7.5	7.5	8
Impact Strength (Charpy), in.-lb			
¼ In. Dia	8.2	10.5–14.0	8.9–11.4
½ In. Dia	—	3.8–5.0	5.50–5.64
Flexural Strength, 1000 psi	5.4–12.0	11–20	18.5–22.0
Compressive Strength, 1000 psi	49.1–70.0	66–90	60–100
ELECTRICAL PROPERTIES			
Volume Resistivity, ohm-cm			
68–77 F	$10^{13}–10^{15}$	$>10^{14}$	$>10^{14}$
212 F	1.2×10^{8} [c]	$0.21–>100 \times 10^{13}$	2.0×10^{13}
570 F	5.0×10^{6}	$0.6–800 \times 10^{8}$	5.5×10^{11}
930 F	4.0×10^{5} [d]	$0.32–300 \times 10^{6}$	5.5×10^{8}
1290 F	—	$2.3–500 \times 10^{6}$	1.4×10^{7}
1650 F	—	$7.0–680 \times 10^{3}$	8.2×10^{5}
Dielectric Strength, v/mil	55–300	145–280	60–290
Dielectric Constant			
60 Cycles	5.4–7.0	5.9–6.3	9.1
1 Mc	—	5.5–6.51	5.30–9.20
100 Mc	—	5.6–6.0	8.6
10,000 Mc	—	5.3–5.8	8.4
Dissipation Factor			
60 Cycles	0.0090–0.0112	0.0013–0.0150	0.0360
1 Mc	—	0.0011–0.0075	0.0007–0.0022
100 Mc	—	0.0009–0.0028	0.0012
10,000 Mc	—	0.0014–0.0054	0.0027
Loss Factor			
60 Cycles	0.053–0.060	0.008–0.090	0.327
1 Mc	—	0.007–0.0252	0.0041–0.0135
100 Mc	—	0.005–0.016	0.010
10,000 Mc	—	0.008–0.030	0.023
Te Value, F [a]	680–842	824–1544	1292–1598
Temp Coef of Capacitance Chg [b]	630	120	175
HEAT RESISTANCE			
Max Rec Svc Temp, F	1820	1832	2012
USES	Low voltage insulators, vitrified high voltage insulators, wire supports, outlet boxes, lightning arrestors, suspension insulators, x-ray rods and tubes	Aircraft insulators, appliance housings, electric line insulators, tube sockets, electrical instrument spacers and feedthrough bushings, fuel igniters, camera and projector rollers, thermostat controls	Aircraft firewall connector plugs and glow plugs; electronic tube sockets, coil forms, spacers, brackets, printed circuits and plates; pump valves, plungers and seats

[a] Te value is the temperature at which a cubic centimeter of the material has a resistance of 1 megohm.
[b] 77-185 F, parts per million. [c] 392 F [d] 752 F

Mica—Sheet, Molded

Type →	Natural Muscovite	Synthetic Fluor-Phlogopite	Glass-Bonded Synthetic[a]	
			Insulation	Capacitor
PHYSICAL PROPERTIES				
Specific Gravity	2.6–3.2	2.9	3.0, 2.6–3.8	3.25, 3.5–3.8
Ther Cond, Btu/hr/sq ft/°F/ft	0.25–0.36	0.3–0.4	0.29, 0.23–0.31	—
Coef of Ther Exp, per °F	1.8×10^{-5}	$1.44–2.70 \times 10^{-5}$	$0.58–0.62 \times 10^{-5}$	$1.8, 1.8–2.0 \times 10^{-5}$
Spec Ht, Btu/lb/°F	0.20	0.25	0.16, 0.13–0.24	—
Water Absorption	Low	Low	Nil	Nil
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	$20–30 \times 10^6$	25×10^6	$9–12, 7–8 \times 10^6$	$9–12, 7–8 \times 10^6$
Ten Str, 1000 psi	40–50	45–55	6–7, 5–6	6, 5
Hardness				
Knoop	90	200	M110–120,[b] M115–130[b]	—
Mohs	3–4	3.4	—	—
Impact Str (Izod notched), ft-lb/in.	—	—	1.8, 0.7	—
Flex Str, 1000 psi	—	—	15–18, 10–15	12–15, 10–15
Compr Str, 1000 psi	>150	>150	35–42, 20–25	35–42, 20–25
ELECTRICAL PROPERTIES				
Vol Res, ohm-cm	$10^{13}–10^{17}$	$10^{13}–10^{17}$	$10^{14}–10^{16}, 10^{14}–10^{17}$	$10^{14}, 10^{14}$
Dielec Str (step by step, ¼ in.), v/mil	1000–2000	1000–2000	400–600, 400–500	270–400, 300–400
Dielec Const				
60 Cycles	5.4–8.7	6.5	7.5–7.6, 7.0–9.5	—
10^6 Cycles	5.4–8.7	6.5	7.4–7.9, 6.9–9.2	10–25, 10–40
Dissip Factor				
60 Cycles	0.0025	0.002–0.004	0.0035–0.0070, 0.007–0.050	0.0020–0.0040, 0.0025
10^6 Cycles	0.0001–0.0004	0.0001–0.0003	0.0015–0.0020, 0.0015–0.0120	0.0035
Arc Resistance, sec	High	High	300, 250	300, 250
FABRICATING PROPERTIES				
Machinability	Fair, readily punched	Fair, punches more readily than Natural	Fair to good; poor	Fair to good; poor
Moldability	—	—	Fair; good	Fair; good
HEAT RESISTANCE				
Max Rec Svc Temp, F	1110	1400–1800	600–1000*, 500–800[c]	600–700, 500–600
Heat Dist Temp (264 psi), F	—	—	850, 700	800, 650
Ther Shock Res	—	—	Moderate	Moderate
CHEMICAL RESISTANCE	Good res to most chemicals and molten materials exc hydrofluoric acid. Oils generally cause delamination	Slightly better chemical res than Natural; high res to oils. High res to high pressure, high temp water	Good res to organic solvents; poor res to strong acids and alkalis	Good res to organic solvents; fair res to strong acids and alkalis
USES	Furnace peepholes, boiler gage glass; capacitors, tube spacers	Experimental high temp tube spacers and waveguide windows; used to make glass-bonded synthetic mica	Electromechanical devices, high temp (660–900 F) insulators requiring high stability (e.g., computer parts)	Stable capacitors, tuners; high temp uses

[a] The first value or range in each column refers to glass-bonded mica produced by compression molding, the second to transfer molding.
[b] Rockwell.
[c] A modified type with a max svc temp of 1550 F is called "ceramoplastic" by its producer.

Refractory Ceramics and Cermets—Fired or Sintered Parts

HIGH ALUMINA CERAMICS[a]

Type (% alumina) →	85%	95%	99+%
PHYSICAL PROPERTIES			
Specific Gravity	3.45	3.65	3.85
Ther Cond (200 F), Btu/hr/sq ft/°F/ft	6.2	10.3	10.7
Coef of Ther Exp, per °F			
77–390 F	3.1×10^{-6}	3.7×10^{-6}	—
77–750 F	3.7×10^{-6}	4.0×10^{-6}	—
77–1100 F	3.9×10^{-6}	4.3×10^{-6}	4.3×10^{-6}
77–1470 F	4.1×10^{-6}	4.5×10^{-6}	—
77–1830 F	4.3×10^{-6}	4.7×10^{-6}	—
Water Absorption, %	0.0	0.0	0.0
Max Rec Svc Temp, F	2460	3000	3540
ELECTRICAL PROPERTIES			
Dielec Str, v/mil	200	250	300
Dielec Const (77 F, 1 mc)	8.2	8.9	9.6
Power Factor (77 F, 1 mc)	0.0009	0.00035	0.00027
Loss Factor (77 F, 1 mc)	0.007	0.003	0.003
Te Value, F	1560	1960	2012
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	32×10^6	40×10^6	50×10^6
Ten Str, 1000 psi	20	30	39
Flex Str, 1000 psi	41	45	47
Compr Str, 1000 psi	250	300	400
Hardness			
Mohs	9	9	9
Knoop	1450	1750	—
Impact Str (Charpy), in.-lb	6.5	7.0	—

[a] The values given are not maximum values and are dependent upon the minor components or fluxes used as well as a number of other factors.

ALUMINA CERMETS

Type →	Chromium-Alumina	Molybdenum-Chromium-Alumina[a]
PHYSICAL PROPERTIES		
Density, lb/cu in.	0.21	0.22
Porosity, %	<0.25	<0.25
Melting Point (approx), F	3362	—
Ther Cond, Btu/hr/sq ft/°F/ft	29[a]	—
Coef of Ther Exp, per °F	4.7×10^{-6}[b]	5.2×10^{-6}[c]
Spec Ht (calc), Btu/lb/°F	0.16	0.14
Poisson's Ratio	0.22	0.25–0.27
MECHANICAL PROPERTIES		
Mod of Elast in Tension, 10^6 psi	41×10^6	$37–39 \times 10^6$
Ult Ten Str, 1000 psi		
Rm Temp	21	—
800 F	20.5	—
1200 F	20	—
1500 F	19.7	—
1800 F	16.8	—
2000 F	11.7	—
Hardness (Rockwell)	C37	C45–55
Mod of Rupture, 1000 psi		
Rm Temp	45	55[d]
1800 F	27	55
2100 F	18	29
2400 F	4.6	12
Compr Str, 1000 psi	110	240
Mod of Rigidity, psi	17×10^6	15×10^6
Shear Str, 1000 psi	40	—
Bulk Modulus, psi	21×10^6	26×10^6

[a] At 500 F. [b] At 32–1832 F. [c] At 68–1472 F.
[d] Addition of tungsten raises room temperature modulus of rupture to about 70,000 psi.

REFRACTORY OXIDES

Type →	Beryllia (BeO)	Calcia (CaO)	Magnesia (MgO)	Thoria (ThO_2)	Zirconia (stabilized ZrO_2)	Silica (vitreous SiO_2)
Melting Point, F	4620	4710	5070	6000	4710	—
Ther Cond (at spec temp and porosity), Btu/hr/sq ft/°F/ft	9.52 (2190 F, 5–10%)	4.12 (1830 F, 9%)	1.47 (2190 F, 22%)	0.0 (2190 F, 17%)	0.53 (2190 F, 28%)	0.80 (0.9%)
Coef of Ther Exp, per °F	52.8×10^{-7} (68–2550 F)	75.5×10^{-7} (68–2190 F)	77.8×10^{-7} (68–2550 F)	52.8×10^{-7} (68–2550 F)	30.6×10^{-7}[a] (68–2190 F)	2.8×10^{-7} (68–2280 F)
Max Use Temp in Oxidizing Atm, F	4350	4350	4350	4890	4530	—
Hardness (Mohs)	9	4.5	6	7	7–8	—
Thermal Shock Resistance	Excellent	Fair	Fair	Poor	Fair	Excellent
Stability in —						
Reducing Atmosphere	Excellent	Poor	Poor	Good	Good	Fair
Carbon	Excellent	Poor	Good	Fair	Fair	Good
Acid Slags	—	Poor	Poor	Poor	Good	Good
Basic Slags	Fair	Fair	Good	Good	Poor	—
Metals	Good	Fair	Fair	Excellent	Good	—

[a] Depends on degree of stabilization.

continued on next page

Refractory Ceramics and Cermets—Fired or Sintered Parts

CARBIDES

Type →	Silicon Carbide			Boron Carbide
	Silicate-Bonded	Silicon Nitride-Bonded	Densified	
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.093	0.104	0.112	0.087[a]
Porosity, %	9–17	6–10	Negligible	Negligible
Ther Cond (2200 F), Btu/hr/sq ft/°F/ft	9	10	25[b]	16
Coef of Ther Exp (0–2550 F), per °F	2.4×10^{-6}	2.4×10^{-6}	2.17×10^{-6}	1.73×10^{-6}
Specific Heat (0–2550 F), Btu/lb/°F	0.285	0.288	0.331	—
Max Service Temperature, F				
Inert Atmosphere	3200	3200	4000	4100
Oxidizing Atmosphere	2900	3000	3000	1000
MECHANICAL PROPERTIES				
Mod of Elast in Tension (77 F), psi	13.2×10^6	17×10^6	68×10^6	42×10^6
Tensile Strength (77 F), 1000 psi	Very low	3	25	22.5
Compressive Strength (77 F), 1000 psi	15	20	150	420
Modulus of Rupture (77 F), 1000 psi	2.2	5.5	24	50

[a] Boron carbide is available in densities ranging from 0.069 to 0.091 lb per cu in. [b] 1832 F.

CARBIDE-BASE CERMETS

Type (base) →	Titanium Carbide (TiC)[a]	Tungsten-Titanium Carbide ($WTiC_2$)[b]	Tungsten Carbide (WC)	Chromium Carbide (Cr_4C, Cr_7C_3, Cr_3C_2)[c]
Density, lb/cu in.	0.20–0.26	0.38–0.47	0.47–0.55	0.25–0.29
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	—	16.5–32.9	25.7–50.1	—
Coef of Ther Exp (68–1200 F), per °F	$4.3–7.5 \times 10^{-6}$	$3.5–4.0 \times 10^{-6}$	$2.5–3.9 \times 10^{-6}$	$5.8–6.3 \times 10^{-6}$[f]
Electrical Conductivity, % IACS	1.34–6.0	4.3–5.8	5.0–10.1	2.58–2.78
Mod of Elast in Tension, psi				
70 F	$42–57 \times 10^6$	$65.5–80.6 \times 10^6$	$61.6–94.3 \times 10^6$	—
1600–1800 F	$33–48 \times 10^6$	—	—	—
Tensile Strength, 1000 psi[d]				
75 F	26–134 (0–61)	118–145	130[e]	36–37 (0)
1500 F	45–94 (0–2.7)	—	—	20–42 (0.2)
1800 F	35–72 (0–2.4)	—	—	—
Hardness (Rockwell)	A73–A91	A90–A93	A85–A93	A86.5–A89
Impact Strength (unnotched Charpy), ft-lb				
75 F	1.5–16	5.3–8.9	—	—
1800 F	2.5–16	—	—	—
Transverse Rupture Strength, 1000 psi	122–236	125–350	175–460	100–120
Stress-Rupture Strength (100 hr, 1800 F), 1000 psi	8–28	—	—	—
Compressive Strength, 1000 psi	265–450	585–705	518–800	422–480

[a] Property range covers grades ranging from 17.5% to 90% TiC with different binder metal contents.
[b] Property range covers various grades of different carbide-metal proportions.
[c] The type of chromium carbide and the type of binder metal affects properties.
[d] Elongation (%) in parenthesis. [e] Typical of one grade. [f] 68–576 F.

Refractory Ceramics and Cermets—Fired or Sintered Parts

OTHER CARBIDES

Type →	Beryllium Carbide (Be_2C)	Titanium Carbide (TiC)	Columbium Carbide (CbC)	Tantalum Carbide (TaC)	Zirconium Carbide (ZrC)
Ther Cond (68–795 F), Btu/hr/sq ft/°F/ft	12.1	9.9[a]	8.23[a]	12.8[a]	11.9[a]
Coef of Ther Exp (77–1472 F), per °F	5.8×10^{-6}	4.1×10^{-6}	—	4.6×10^{-6}	3.7×10^{-6}
Electrical Resistivity, ohm-cm[a]	1.1	1.05×10^{-4}	7.4×10^{-5}	2×10^{-5}	6.34×10^{-5}
Hardness (Mohs')	9+	8–9	9–10	9+	8–9
Compressive Strength, 1000 psi[a]	105	109	—	—	238
Mod of Rupture, 1000 psi[a]	16	—	—	—	—
Ther Shock Res (air quenched), cycles at designated temp range (F)	4 at 2000–1470	—	—	—	—
Fabrication Methods	Hot pressing, steel die pressing and sintering, hydrostatic pressing and sintering	Hot pressing, steel die pressing and sintering	Hot pressing, steel die pressing and sintering	Hot pressing, steel die pressing and sintering	Hot pressing, steel die pressing and sintering

[a] Room temperature.

MOLYBDENUM DISILICIDE (MoS_2)

Type →	Cold Pressed, Sintered	Hot Pressed
PHYSICAL PROPERTIES		
Density, lb/cu in.	0.216	0.224
Melting Point, F	3685 ±90	3685 ±90
Electrical Resistivity, microhm-cm		
77 F	—	21.5–27.2
2900 F	—	75–80
Coef of Ther Exp (78–2700 F), per °F	—	5.1×10^{-6}
MECHANICAL PROPERTIES		
Tensile Strength, 1000 psi		
1800 F	—	40
2000 F	—	42
2200 F	—	43
2400 F	—	41
Hardness		
Rockwell	C57[a]	A80–87[b]
Knoop (1 kg)	1065	850–870
Compressive Strength, 1000 psi	100[c]	350
Modulus of Rupture, 1000 psi		
77 F	51	36–57
1800 F	51–67	—
2000 F	51–86	72
2200 F	[d]	55
Stress-Rupture Strength (100 hr), 1000 psi		
1600 F	—	35
1800 F	—	29
1900 F	—	13.5
2000 F	—	8.5

[a] Superficial hardness.
[b] Some indentation cracking.
[c] Cast specimens.
[d] Test not applicable because bars showed too much plasticity.

NITRIDES

Type →	Boron Nitride	Silicon Nitride[a]
PHYSICAL PROPERTIES		
Density, lb/cu in.		
Theoretical	0.081	0.124
Actual	0.076	0.111
Melting Point, F	>3000[b]	3452[c]
Ther Cond, Btu/hr/sq ft/°F/ft	16.6, 15.4[d]	0.90[e]
Coef of Ther Exp (70–1800 F), per °F	4.3	1.37
MECHANICAL PROPERTIES		
Mod of Elast in Tension, 10^6 psi		
75 F	12.4×10^6	—
1300 F	1.5×10^6	—
Hardness		
Mohs	2	—
Rockwell	—	A99
Modulus of Rupture, 1000 psi		
75 F	15.9	10
1300 F	3.8	—
ELECTRICAL PROPERTIES		Not applicable
Volume Resistivity, ohm-cm		
75 F	1.7×10^{13}	
900 F	2.3×10^{10}	
1800 F	3.1×10^4	
Dielectric Constant (10^3–10^6 cps)	4.15	
Dissipation Factor		
10^3 Cycles	0.00103	
10^6 Cycles	0.00020	
10^{10} Cycles	0.0003	

[a] Mechanical properties are given for direction parallel to direction of forming pressure. Values perpendicular to this direction may be one-half to one-quarter of these values.
[b] May be used continuously at 3000 F, and higher under special conditions.
[c] Sublimes.
[d] Values at 570 F and 1800 F, respectively.
[e] 400–2400 F.

Glass (Industrial)—Flat, Pressed, Blown

Type →	Fused Silica	96% Silica	Soda-Lime Glasses		Alumino-Silicate
			Plate	General Purpose	
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.079	0.078	0.09	0.089	0.091
Softening Point, F	3050	2800	1330	1285	1675
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	0.80	0.80	0.53	0.53	—
Coef of Ther Exp (32-570 F), per °F	0.30×10^{-6}	0.45×10^{-6}	4.8×10^{-6}	5.1×10^{-6}	2.3×10^{-6}
Spec Ht, Btu/lb/°F	0.185	0.178	0.20	0.20	0.180
Elec Res (212 F), ohm-cm	$>10^{15}$	$>10^{15}$	—	4×10^{9}	$>10^{15}$
Power Factor (68 F, 1 mc), %	0.001	0.02–0.04	0.80	0.90	0.16
Dielec Const (68 F, 1 mc)	3.8	3.8	7.4	7.2	6.3
Ther Stress Res, °F[a]	—	390	—	65	85
Ther Shock Res, °F[b]	Very high	Very high	135	125	240
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	10.2×10^{6}	9.7×10^{6}	$9–10 \times 10^{6}$	$9–10 \times 10^{6}$	12.7×10^{6}
Normal Work Stress (annealed), psi	1000	1000	1000	1000	1000
Max Rec Svc Temp, F					
Annealed	1650	1500	900	840	1200
Tempered	—	—	550	480	840
THERMAL TREATMENT					
Annealing Temp (stress relief), F	2080	1670	1010	950	1315
FABRICATING PROPERTIES					
Workability	Glass can be ground or polished without great difficulty. Machining limited to sawing or drilling. Sawing readily accomplished with an impregnated wheel. Drilling is difficult, but is done with special carbide-tipped drills using kerosene as a lubricant				
Joining	Glass can be joined by heat sealing using a blast lamp, a gas torch or electric heating. Parts must have closely similar coefficients of expansion; otherwise, intermediate pieces having intermediate coefficients must be used. Glass-to-metal seals are also made by this latter process				
CHEMICAL RESISTANCE	Glass is attacked by hydrofluoric acid, hot concentrated phosphoric acid and strong alkalis. It is resistant to most other chemicals				
USES	Ultraviolet energy transmission, chemical apparatus, thermocouple protection tubes, laboratory apparatus	Ultraviolet energy transmission, chemical reaction vessels, thermocouple protection tubes, laboratory apparatus	Sheet and plate glass, molded glassware, bulbs for electric lamps, bottles, vials, fluorescent lamp tubing		

[a]Measured by subjecting the two sides of a tube or constrained plate to a temperature differential. Index is the differential that causes a stress of 1000 psi on cooler surface.

[b]Measured by heating squares of annealed glass, 6 by 6 by ¼ in., to a uniform temperature and dropping into cold water. Index is maximum temperature differential at which no breakage occurs.

Glass (Industrial)—Flat, Pressed, Blown

Type →	Borosilicate Glasses			Lead Silicate Glasses	
	Low Expansion Chemical Resistant	Baking and Kovar Sealing	Low Electrical Loss	Lamp Tubing	High Lead
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.080	0.081–0.082	0.077	0.110	0.154
Softening Point, F	1500	1300–1425	—	1160	1075
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	0.67	—	0.67	0.50	0.45
Coef of Ther Exp (32–570 F), per °F	1.85×10^{-6}	$2.0–2.5 \times 10^{-6}$	1.8×10^{-6}	5.0×10^{-6}	5.1×10^{-6}
Spec Ht, Btu/lb/F	0.195	0.195	—	0.17	0.16
Elec Res (212 F), ohm-cm	10^{12}	3×10^{13}	$>10^{15}$	10^{14}	$>10^{15}$
Power Factor (68 F, 1 mc), %	0.46	0.26–0.28	0.06	0.16	0.09
Dielec Const (68 F, 1 mc)	4.6	4.7–5.1	4.0	6.6	9.5
Ther Stress Res, °F[a]	—	—	—	65	—
Ther Shock Res, °F[b]	320	—	—	120	—
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	9.8×10^6	—	6.8×10^6	9.0×10^6	7.6×10^6
Normal Work Stress (annealed), psi	1000	1000	1000	1000	1000
Max Rec Svc Temp, F					
Annealed	900	800–840	810	720	720
Tempered	550	420–500	450	380	360
THERMAL TREATMENT					
Annealing Temp (stress relief), F	1020	890–975	910	800	800
FABRICATING PROPERTIES					
Workability	Glass can be ground or polished without great difficulty. Machining limited to sawing or drilling. Sawing readily accomplished with an impregnated wheel. Drilling is difficult, but is done with special carbide-tipped drills using kerosene as a lubricant				
Joining	Glass can be joined by heat sealing using a blast lamp, a gas torch or electric heating. Parts must have closely similar coefficients of expansion; otherwise, intermediate pieces having intermediate coefficients must be used. Glass-to-metal seals are also made by this latter process				
CHEMICAL RESISTANCE	Glass is attacked by hydrofluoric acid, hot concentrated phosphoric acid and strong alkalis. It is resistant to most other chemicals				
USES	Heat exchanger tubes, chemical apparatus, cooking ware, electrical insulators, sight and gage glasses, containers for chemicals and medicines, metal sealing, industrial piping, industrial glassware requiring thermal resistance, special lighting ware, heat resisting lenses			Lamp tubing, electrical and electronic applications, thermometer tubing, metal sealing	Electrical capacitors, x-ray shielding

[a] Measured by subjecting the two sides of tube or constrained plate to a temperature differential. Index is the differential that causes a stress of 1000 psi on cooler surface.

[b] Measured by heating squares of annealed glass, 6 by 6 by ¼ in., to a uniform temperature and dropping into cold water. Index is maximum temperature differential at which no breakage occurs.

Carbon and Graphite—Molded, Extruded

Material →	Carbon (Petroleum coke base)	Graphite
PHYSICAL PROPERTIES		
Density, lb/cu ft	93.3–102.0	90–116
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	3–5	70–120
Coef of Ther Exp (70–212 F), per °F	1.3–1.5 x 10^{-6}	1.0–1.3 x 10^{-6}
Specific Heat (100 F), Btu/lb/°F	0.18	0.18
MECHANICAL PROPERTIES[d]		
Mod of Elast in Tension, psi	1.6–2.3 x 10^{6}	0.5–1.8 x 10^{6}
Tensile Strength, psi	900–1100	440–2000
Compressive Strength, psi	6300–9000	1800–8500
Flexural Strength, psi	2500–3000	800–3300
Hardness (scleroscope)	30–50	8–45
ELECTRICAL PROPERTIES		
Electrical Resistivity (68 F), microhm-cm	3500–4600	800–1300
Contact Resistance, ohms/sq in.		
Against Carbon	0.0058, 0.0026, 0.0017[a]	—
Against Copper	0.0133, 0.0093, 0.0042[a]	0.000704, 0.000315, 0.000162, 0.0000555[b]
Against Brass	0.038, 0.012, 0.0052[a]	0.00092, 0.000214, 0.000109[c]
Against Aluminum	0.138, 0.078, 0.015[a]	0.0448, 0.0067, 0.0020[c]
Against Graphite	—	0.000473, 0.00175, 0.000064, 0.000031[b]
Against Steel	—	0.01309, 0.00438, 0.00177, 0.000737[b]
FABRICATING PROPERTIES	Powdered material mixed with binder and shaped by molding or extrusion, then baked at approx 1800 F for carbon, 4500 F for graphite	
CHEMICAL RESISTANCE	Carbon begins to oxidize in air at approximately 630 F and graphite at approximately 810 F, although the rate of oxidation is not rapid even at high temperatures. With a steam or a carbon dioxide atmosphere, temperature can be raised above a red heat before excessive oxidation occurs. Alkalis in solution do not attack these materials but fused hydroxides and carbonates attack them at high temperatures. They are not attacked by dilute acids, including hydrofluoric, but strongly oxidizing chemicals will attack them	
USES[e]	Mechanical: sealing rings, pump and valve parts, bearings, pistons, and piston rings. Electrical: battery carbons, contacts, welding carbons, anodes, brushes for electrical machines. Refractory: linings, molds, continuous casting dies, furnace boats, brazing jigs. Chemical: pipe, pumps, fittings, heat exchangers, valves, towers and accessories, porous filtering media. Nuclear: neutron moderator, reflector, structural, fuel element matrix	

[a] Pressures of 5, 25 and 75 psi, respectively.
[b] Pressures of 25, 150, 400 and 1000 psi, respectively.
[c] Pressures of 25, 150 and 400 psi, respectively.
[d] Strength of graphite generally increases with increasing temp.
[e] There are now available 1) special carbon-graphite mixtures for mechanical applications (especially seal rings) and 2) flexible graphitized industrial textiles for a variety of applications requiring the properties of graphite plus flexibility.

Natural Fibers

Type →	Cotton	Bast				Hard			Animal		
		Flax	Jute	Hemp	Ramie	Manila (abaca)	Sisal	Henne-quin	Wool	Horse-hair	Silk
NATURE OF FIBER											
Length, in.	½–2½	6–40	10–60	40–80	15–25	20–40	24	20	1½–15	1–25	Filament
Width, μ	17	16	17	20	47	19	19	20	28	100	11
Cross Section	Flat tube	Tube	Bunched cells	—	Flat tube	Bunched cells	Bunched cells	Bunched cells	Round	Round	Round
PHYSICAL AND MECHANICAL PROPERTIES											
Specific Gravity	1.55	1.50	1.48	1.48	1.55	—	—	—	1.30	1.30	1.25–1.35
Breaking Tenacity, gm/den											
70 F, 65% RH	3.0–4.9	6.3	3.0–5.9	5.9–6.9	6.5	6.0–7.5	4.1	3.0–3.5	1.0–1.7	—	2.8–5.2
Wet	3.3–6.37	—	—	—	—	6.0–8.5	—	2.5–3.0	0.76–1.63	—	2.1–4.9
Ten Str (70 F, 65% RH), 1000 psi	44–109	115	57–112	112–132	130	125	100–120	—	20–29	—	45–83
Breaking Elongation, %											
70 F, 65% RH	3–7	3	—	2–6	3–6	2–3	2–2.5	—	25–35	—	13–31
Wet	—	—	—	—	—	—	—	—	25–50	—	—
Stiffness (avg), gm/den[a]	57–60	270	185	200	167	175	127	—	3.9	—	18
Strain Recovery (at 2%), %[b]	74, 45 (5%)	65	74 (1%)	—	52	—	—	—	99, 63 (20%)	99, 63 (20%)	92
Toughness (avg), gm-cm/den-cm	0.15	0.09	0.03	—	—	—	—	—	0.25	—	0.44
Moisture Regain (70 F, 65% RH), %	7	12	13.75	11.75	12	—	—	—	16	—	11
RESISTANCE TO ENVIRONMENTS											
Acids											
Strong	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Good[d]	—	Poor
Weak	Poor (hot)	Poor	—	Poor	—	—	—	—	Good	—	Fair
Alkalis											
Strong	Exc	Good	Good	Good	Good	Good	Good	Good	Poor	Poor	Poor
Weak	Exc	Good	Good	Good	Good	Good	Good	Good	Attacked	Poor	Poor (hot)
Other Chemicals	Show generally good resistance to organic solvents; cotton bleached by hyperchlorites and peroxides; swells and disintegrates in cuprammonium hydroxide								Bleached by perox-ides or SO_2	Resistant	Resistant
Heat	Good to 275 F	Good to 275 F	—	Good to 275 F	Good to 275 F	—	—	—	Good to 212 F	—	Disinte-grates at 340 F
Sunlight (prolonged exposure)	Weak-ened	None	None	None	None	None	None	None	Weak-ened	Weak-ened	Weak-ened
Microorganisms	Poor	Very good	Good	Good	Exc	Good	Poor	Poor	Fair	Fair	Good
Flame[c]	Burns	Burns	Burns	Burns	Burns	Burns	Burns	Burns	Slow burn	Slow burn	Burns

[a] Ratio of breaking stress to breaking strain (i.e., gm/den to rupture divided by strain in cm/gage cm at breaking stress).
[b] Recovery after 2% strain, except where specific percentage strain is given in parentheses.
[c] Basic flammability of untreated fiber.
[d] Except hot H_2SO_4.

Synthetic Fibers

Type →	Regenerated Cellulose (rayons)				Cellulose Esters		Fluorocarbon
	Viscose		Saponified Acetate				
	Regular to Medium Tenacity	High Tenacity	Fortisan	Fortisan 36	Cellulose Acetate	Cellulose Triacetate (Arnel)	TFE (Teflon)
NATURE OF FIBER							
Length, in.	Staple, filament	Filament	Filament		Staple, filament	Staple, filament	Filament
Width, μ	8.4–4.3	10–15	3–9		11–46	—	—
Cross Section	Irregular	Irregular	Irregular		Clover leaf	Clover leaf	Circular
PHYSICAL AND MECHANICAL PROPERTIES							
Specific Gravity	1.46-1.52	—	1.5	1.5	1.32	1.3	2.3
Breaking Tenacity, gm/den							
70 F, 65% RH	1.5–3.2	3.0–5.0	6–7	8	1.3–1.5	1.2–1.4	1.6
Wet	0.7–1.9	1.9–3.6	5.1–6.0	6.0–6.4	0.8–1.2	0.8–1.0	1.6
Ten Str (70 F, 65% RH), 1000 psi	29–65	65–105	136	155	22–28	20–26	47
Breaking Elongation, %							
70 F, 65% RH	15–30	9–22	6	6.2	23–34	22–28[d]	13
Wet	17–40	14–30	6	6	30–45	30–40	13
Stiffness (avg), gm/den[a]	11.1–16.6	25.5–29	117	135	5.5	5.2	12
Strain Recovery (at 2%), %[b]	30–97	70–100	100 (20%), 60 (40%)	85, 70 (5%)	48–65 (4%)	88 (3%), 43 (10%)	—
Toughness (avg), gm-cm/den-cm	0.19–0.21	0.22–0.30	0.21	0.26	0.17	0.16	0.12
Moisture Regain (70 F, 65% RH), %	13	13	10.7	9.6	6	3.2	None
RESISTANCE TO ENVIRONMENTS							
Acids							
Strong	Similar to cottons, i.e., disintegrated by hot dilute or cold concentrated acids		Similar to cotton		Decomposed	Similar to acetate	Inert
Weak					Good		
Alkalis							
Strong	Swell; strength reduced				Saponifies	Saponifies	Inert
Weak	Good				Res (cold)	Res (cold)	Inert
Other Chemicals	Attacked by strong oxidizing agents; not damaged by hypochlorite or peroxide bleaches				Similar to viscose	Similar to viscose	Only affected by alkali metals and some hot, pressurized halogenated hyd.
Heat	Lose strength at 300 F. Decompose at 350–400 F				Sticky at 350–375 F; softens at 400–475 F; melts at 500 F	When heat treated will not stick at 480 F; melts at 575 F	Nondegraded at 400 F; extremely slow sublimation at 55 F
Sunlight (prolonged exposure)	Weakened		Resistant		Weakened	Weakened	Inert
Microorganisms	Attacked		Attacked		Resistant	Resistant	Inert
Flame[c]	Highly flammable		Burns		Burns slowly	Burns slowly	Self-exting

[a] Ratio of breaking stress to breaking strain (i.e., gm/den to rupture divided by strain in cm/gage cm at breaking stress).
[b] Recovery after 2% strain except where specific percentage strain is given in parentheses.
[c] Basic flammability of untreated fiber. [d] For filament; 35–40% for staple.

Synthetic Fibers

Type →	Acrylics						
	Polyacrylonitrile (Orlon)	Acrylonitrile-Vinyl Derivatives (Acrilan)	Acrylonitrile-Vinyl Chloride (Dynel)	Modified Acrylic (Verel)	Acrylonitrile-Base (Creslan)	Dinitrile [a] (Darvan)	Nitrile [b] Alloy (Zefran)
NATURE OF FIBER							
Length, in	Staple	Staple	Staple	Staple	—	—	—
Width, μ	14-27	15-30	—	—	—	—	—
Cross Section	Dogbone	—	—	—	—	—	—
PHYSICAL AND MECHANICAL PROPERTIES							
Specific Gravity	1.14	1.17	1.3	1.37	1.17	1.18	1.19
Breaking Tenacity, gm/den							
70 F, 65% RH	2.2-2.6	2.5	2.5-3.3	2.5-2.8	3.3	1.75	3.5
Wet	1.8-2.1	2.0	2.5-3.3	2.4-2.7	3.3	1.5	3.1
Ten Str (70 F, 65% RH), 1000 psi	32-39	37-40	40-57	42-47	41	26	53
Breaking Elongation, %							
70 F, 65% RH	20-28	36	30-42	33-35	32	30	33
Wet	26-34	44	30-42	32-34	32	30	33
Stiffness (avg), gm/den [c]	10	7	8.2	8.0	10.3	6	11
Strain Recovery (at 2%), % [d]	—	99, 89 (5%)	94	88 (4%), 55 (10%)	90 (1%), 48 (5%)	100 (3%), 75 (5%)	99, 72 (10%)
Toughness (avg), gm-cm/den-cm	0.40	0.46	0.53	0.46	0.53	0.3	0.58
Moisture Regain (70 F, 65% RH), %	1.5	1.2	0.3-0.4	3.5-4	1.3	2-3	2.5
RESISTANCE TO ENVIRONMENTS							
Acids							
Strong	Good-exc	Good-exc	Good	Exc	Good-exc	Good-exc	Exc
Weak	Exc	Exc	Exc	Exc	Exc	Exc	Exc
Alkalis							
Strong	Poor	Poor	Good	Discolors some, no weakening	Poor	Poor	Fair
Weak	Fair-good	Fair-good	Exc		Fair-good	Fair-good	Good
Other Chemicals	Not harmed by solvents, oils, greases and some acid salts	Similar to Orlon	Good; softened by acetone and some ketones	Good; dissolves in warm acetones	Good	Good	Good
Heat	No weakening after 32 days at 257 F; sticking temp 455 F [f]	5% shrinkage at 487 F	Unless heat treated, shrinks at 250 F	Exposure over 300 F causes stiffening	Sticking temp 450 F [f]	Unaffected by 195 days at 300 F; sticking temp 340 F [f]	Sticking temp 490 F [f]
Sunlight (prolonged exposure)	Very resistant	Resistant	Weakened	—	—	Resistant	Resistant
Microorganisms	Resistant	Resistant	Resistant	—	—	Resistant	Resistant
Flame [e]	Burns slowly	Burns slowly	Self-exting	Self-exting	Burns	Burns	Burns

[a] Though not an acrylic (actually a polymer of vinylidene cyanide), it is grouped here because of similarities of properties.
[b] Nitrile "alloy" based on acrylonitrile.
[c] Ratio of breaking stress to breaking strain (i.e., gm/den to rupture divided by strain in cm/gage cm at breaking stress).
[d] Recovery after 2% strain, except where specific percentage strain is given in parentheses.
[e] Basic flammability of untreated fiber.
[f] Copper block method.

continued on next page

Synthetic Fibers

Type →	Polyamides						Polyesters		
	Nylon 66			Nylon 6			Polyethylene Terephthalate (Dacron)		
	Regular	High Tenacity	Staple	Regular	High Tenacity	Staple	Regular	High Tenacity	Staple
NATURE OF FIBER									
Length, in	Filament		Staple	Filament		Staple	Filament		Staple
Width, μ	11–43	16–43	14–43	—		—	11–28		18–25
Cross Section	Round	Round	Round	Round		Round	Circular		—
PHYSICAL AND MECHANICAL PROPERTIES									
Specific Gravity	1.14	1.14	1.14	1.14	1.14	1.14	1.38	1.38	1.38
Breaking Tenacity, gm/den									
70 F, 65% RH	4.6–5.9	5.9–8.8	4.0–4.7	4.5–5.8	6.8–8.6	3.8–5.5	4.4–5.0	6–7	3.8–4.3
Wet	4.0–5.2	5.1–7.6	3.5–4.2	4.3–5.3	5.4–7.5	—	4.4–5.0	6–7	3.8–4.3
Ten Str (70 F, 65% RH), 1000 psi	67–86	86–128	58–69	73–84	109–125	70–80	77–88	106–123	67–76
Breaking Elongation, %									
70 F, 65% RH	26–32	18–28	38–42	24–34	16–17.5	37–40	19–25	9–11	30–36
Wet	30–37	21–32	42–46	28–38	19–24	42–46	19–25	9–11	30–36
Stiffness (avg), gm/den[a]	18	32	10	23	48	17–20	21	65	12
Strain Recovery (at 2%), %[b]	100, 100 (8%)	100 (4%)	—	100, 100 (8%)	100 (4%)	100	97, 80 (8%)	100, 90 (8%)	—
Toughness (avg), gm-cm/den-cm	0.76	0.85	0.87	0.67	0.75	0.64–0.78	0.78	0.50	1.03
Moisture Regain (70 F, 65% RH), %	4.5	4.5	4.5	4.0	4.0	4.0	0.4	0.4	0.4
RESISTANCE TO ENVIRONMENTS									
Acids									
Strong	Dissolves in cold HCl, H_2SO_4 and HNO_3			Degraded by oxidizing agents and mineral acids			Dissolves in H_2SO_4		
Weak	Ultimate disintegration in 5% boiling HCl			Weakens on prolonged exposure to acids such as benzoic and oxalic			Good		
Alkalis									
Strong	Inert			Inert			Disintegrates when boiled		
Weak	Inert			Inert			Good		
Other Chemicals	Good			Good			Good		
Heat	Yellows slightly after 5 hr at 300 F; melts at 482 F			Yellows slightly after 5 hr at 300 F; melts at 420 F			Melts at 480 F		
Sunlight (prolonged exposure)	Weakened			Weakened			Weakened		
Microorganisms	Resistant			Resistant			Resistant		
Flame[c]	Self-exting			Self-exting			Burns slowly		

[a] Ratio of breaking stress to breaking strain (i.e., gm/den to rupture divided by strain in cm/gage cm at breaking stress).
[b] Recovery after 2% strain, except where specific percentage strain is given in parenthesis.
[c] Basic flammability of untreated fiber.

Synthetic Fibers

Type →	Vinyl Derivatives					Polyolefins		
	Vinyl Chloride-Acetate (Vinyon)	Vinylidene Chloride (saran)			Polyvinyl Alcohol (Vinylon)	Polyethylene		Polypropylene
		Monofilament	Filament	Staple		Type I	Type III	
NATURE OF FIBER								
Length, in.	Staple	—	—	—	Staple	Monofilament		Monofilament
Width, μ	16–18	1300	50	—	—	250–1300		—
Cross Section	Barbell	Circular	Circular	Circular	Peanut	Circular		Circular
PHYSICAL AND MECHANICAL PROPERTIES								
Specific Gravity	1.33–1.35	1.7	1.7	1.7	1.26–1.30	0.92	0.95–0.96	0.90–0.91
Breaking Tenacity, gm/den								
70 F, 65% RH	0.7–1.0	1.2–2.3	Up to 2	Up to 1.5	4.4–6.0	1.0–3.0	5.0–7.3	5.5–7.0
Wet	0.7–1.0	1.2–2.3	Up to 2	Up to 1.5	3.7–5.0	1.0–3.0	5.0–7.3	5.5–7.0
Ten Str (70 F, 65% RH), 1000 psi	12–17	15–45	44	33	—	11–35	50–90	—
Breaking Elongation, %								
70 F, 65% RH	100–120	20–30	15–25	15–25	15–17	20–80	10–40	12–25
Wet	100–120	20–30	15–25	15–25	—	20–80	10–40	—
Stiffness (avg), gm/den[a]	1.5	7–10	8–12	8–12	24–40	2–12	20–50	—
Strain Recovery (at 2%), %[b]	—	95 (10%)	95 (10%)	95 (10%)	—	90–95 (5%)	Slow	—
Toughness (avg), gm-cm/den-cm	1.3	0.17–0.27	0.125	0.125	0.79–0.92	0.3	—	—
Moisture Regain (70 F, 65% RH), %	Up to 0.5	None	None	None	4.5–5.0	None	None	—
RESISTANCE TO ENVIRONMENTS								
Acids								
Strong	Exc	Exc; fair to conc H_2SO_4			—	Exc to all but oxidizing		Similar to polyethylene
Weak	Exc	Exc			—			
Alkalis								
Strong	Exc	Exc except for ammonium hydroxide			—	Exc	Exc	Exc
Weak	Exc	Exc			—	Exc	Exc	Exc
Other Chemicals	Soluble in some chlorinated hydrocarbons	Some effect from esters and others			—	Some swelling and weakening in benzene, toluene, etc.		Similar to polyethylene
Heat	Tacky, shrinks at 150 F, softens at 170 F, melts at 260 F	Softens at 240–280 F			Melts 420–450 F	Melts at 225 F	Melts at 265–280 F	Melts at 325–335 F
Sunlight (prolonged exposure)	Resistant	Tends to yellow			—	Resistant if pigmented		Resistant if pigmented
Microorganisms	Resistant	Resistant			Resistant	Resistant		Resistant
Flame[c]	Self-exting	Self-exting			Burns slowly	Burns slowly		Burns slowly

[a] Ratio of breaking stress to breaking strain (i.e., gm/den to rupture divided by strain in cm/gage cm at breaking stress).
[b] Recovery after 2% strain except where specific percentage strain is given in parentheses.
[c] Basic flammability of untreated fiber.

Inorganic Fibers

Type →	Glass [a]	Asbestos (chrysotile)	Aluminum Silicate (Fiberfrax)
NATURE OF FIBER			
Length, in.	Filament, staple	Crude ⅜–2 in.	¼–10 in. staple
Width, μ	5–16	0.1	2–20 (mean)
Cross Section	Circular	—	—
PHYSICAL AND MECHANICAL PROPERTIES			
Specific Gravity	2.54	2.4–2.6	2.73
Breaking Tenacity, gm/den			
70 F, 65% RH	6.0–7.3	2.5–3.1	1.4–6.5[b]
Wet	3.9–4.7	—	—
Ten Str (70 F, 65% RH), 1000 psi	200–220	80–100	50–230
Breaking Elongation, %			
70 F, 65% RH	2.0–3.75	—	1.4–2.7[i]
Wet	—	—	—
Stiffness (avg), gm/den[b]	322	—	—
Strain Recovery (at 2%), %[c]	100 (3%)	—	—
Toughness (avg), gm-cm/den-cm	0.07	—	—
Moisture Regain (70 F, 65% RH), %	0	—	—
RESISTANCE TO ENVIRONMENTS			
Acids			
Strong	Attacked only by hydrofluoric and hot phosphoric	Good (cold) to poor (hot)	Seems to have chemical resistance similar to borosilicate glass fibers
Weak	Stable	Good (cold) to poor (hot)	
Alkalis			
Strong	Resists most	Good	
Weak	Resists most	Good	
Other Chemicals	Exc	—	
Heat	600–2000 F[e]	750–1490 F[g]	2300 F max use temp; 3300 F melting point
Sunlight (prolonged exposure)	Inert[f]	Inert	Inert
Microorganisms	Unaffected	Unaffected	Unaffected
Flame[d]	Nonflammable	Nonflammable	Nonflammable

[a] Properties may vary widely depending on glass composition; values here indicative of those of borosilicate.
[b] Ratio of breaking stress to breaking strain (i.e., gm/den to rupture divided by strain in cm/gage cm at breaking stress).
[c] Recovery after 2% strain, except where specific percentage strain is given in parentheses.
[d] Basic flammability of untreated fiber.
[e] Normal glass limited to 600 F; quartz fiber generally useful up to 2000 F, though some shrinkage occurs.
[f] Specific types available with excellent weathering characteristics.
[g] Structure is stable up to 1490 F; at temperatures of 750 F and above, substantial amounts of water of crystallization are lost.
[h] Average is 3.3 gm/den.
[i] Average is 1.7%.

Woods and Wood-Base Compositions

AMERICAN AND IMPORTED WOODS

Type ↓	Moisture Content, %	Specific Gravity (oven dry)	Static Bending		Max Crush Str (par. to grain), 1000 psi	Hardness, lb[a]		Max Shear Str (par. to grain), psi
			Mod of Rupture, 1000 psi	Mod of Elast, 10^6 psi		End	Side	
AMERICAN HARDWOODS[b]								
Ash (white)	12	0.60	15.4	1.8	7.4	1720	1320	1950
Basswood	12	0.37	8.7	1.5	4.7	520	410	990
Beech	12	0.64	14.9	1.7	7.3	1590	1300	2010
Birch (yellow)	12	0.62	16.6	2.0	8.2	1480	1260	1880
Cottonwood (black)	12	0.35	8.3	1.3	4.4	1020	540	350
Elm (rock)	12	0.63	14.8	1.5	7.1	1920	1510	1320
Hickory (shag bark)	12	0.72	20.2	2.2	9.2	2430	—	—
Locust (black)	12	0.69	19.4	2.1	10.2	2480	1580	1700
Maple (sugar)	12	0.63	15.8	1.8	7.8	2330	1840	1450
Oak (red, white)	12, 12	0.63, 0.68	14.3, 15.2	1.8, 1.8	6.8, 7.4	1780, 2000	1580, 1520	1290, 1360
Poplar (yellow)	12	0.42	10.1	1.6	5.5	1190	670	540
Walnut (black)	12	0.55	14.6	1.7	7.6	1370	1050	1010
AMERICAN SOFTWOODS[b]								
Cedar (Port Orford)	12	0.42	11.3	1.3	6.5	1080	730	560
Cedar (Eastern red)	12	0.47	8.8	0.9	6.0	—	900	900
Cypress (Southern bald)	12	0.46	10.6	1.4	6.4	1000	660	510
Douglas Fir (coast type)	12	0.48	12.2	2.0	7.4	1160	900	710
Fir (balsam)	12	0.36	7.6	1.2	4.5	710	510	400
Hemlock (Eastern, Western)	12, 12	0.40, 0.42	8.9, 10.1	1.2, 1.5	5.4, 6.2	1060, 1170	810, 940	500, 580
Pine (Eastern white)	12	0.35	8.6	1.2	4.8	900	480	380
Pine (longleaf, ponderosa)	12, 12	0.58, 0.40	14.7, 9.2	2.0, 1.3	8.4, 5.3	1500, 1160	920, 550	870, 450
Redwood (virgin)	12	0.40	10.0	1.3	6.2	940	790	480
Spruce (sitka)	12	0.40	10.2	1.6	5.6	1150	760	510
IMPORTED WOODS								
Balsa (tropical America)	5	0.14	2.2	0.5	1.0	—	—	—
Lignum Vitae (tropical America)	12	1.09	—	—	11.4	3600	4500	—
Ebony (Africa)	12	—	26.0	2.7	12.9	3430	3220	2480
Teak (Asia)	52	—	11.4	1.7	5.9	915	1038	1107
Mahogany (tropical America)	12	0.50	11.1	1.4	6.4	880	760	1050
Lemonwood (tropical America)	14	0.78	22.3	2.3	9.7	2140	1940	2120

[a] Load required to embed an 0.444-in. ball to half its diameter. [b] Seasoned.

WOOD COMPOSITION BOARD

Material →	Hardboard (fibrous)[a]			Particle Board[b]		Softboard (insulation)[c]	
	Untempered	Tempered	Super Hardboard	Medium Density[d]	Hard Pressed	Structural Insulating	Medium Density
PHYSICAL PROPERTIES							
Specific Gravity	0.08–1.28	0.96–1.28	1.36–1.44	0.42–0.80	0.80–1.28	0.16–0.42	0.42–0.80
Density, lb/cu ft	50–80	60–80	85–90	26–50	50–80	10–26	26–50
Ther Cond, Btu/hr/sq ft/°F/in.	0.80–1.40	1.10–1.50	1.85	0.40–1.0	1.10–1.50	0.27–0.45	0.50–0.60
Water Abs (24 hr), %	3–30	3–20	0.3–1.2	20–75	15–40	—	6–150
Max Linear Exp, %[e]	0.60	0.4	—	0.6	0.85	0.50	0.2–1.3[f]
MECHANICAL PROPERTIES							
Ten Str, psi							
Par. to Surface	3000–6000	4000–7800	7800	500–4000	1000–5000	200–500	800–2000
Perp to Surface	—	—	500	40–400	275–400	10–25	—
Mod of Elast in Bend, 1000 psi	400–800	800–1000	1250	150–700	400–1000	25–125	90–700
Compr Str (par.), psi	1800–6000	4200–6000	26,500	1400–2800	3500–4000	—	500–3400
Mod of Rupture, 1000 psi	3–7	6.5–10	10–12.5	1.5–8.0	3.0–7.5	0.2–0.8	0.4–4.0

[a] Made by felting ligno-cellulosic wood fibers formed by steam exploding or mechanical fiberizing.
[b] Made of flakes, chips, splinters or particles of wood bonded with synthetic resin or other binder.
[c] Made from wood pulp or bagasse (processed sugar cane), bonded by felting properties of fiber.
[d] Does not include extruded board.
[e] Expansion resulting from change in moisture content from equilibrium at 50% RH to equilibrium at 90% RH.
[f] For homogeneous and laminated boards, respectively.

Wool Felts—Roll[a]

Grade →	18R1	16R1	16R2	16R3	12R1	12R2
SAE Spec. No. →	—	F-1	F-2	F-3	F-5	F-6
GENERAL PROPERTIES						
Wool Content (fiber basis), min %	100	100	100	95	100	100
Standard Thickness Range, in.	⅛ to 1	⅛ to 1	⅛ to 1	⅛ to 1	⅛ to 1	⅛ to 1
Standard Width, in.	60	60	60	60	60	60 or 72
Texture	Fine	Fine	Med fine	Medium	Fine	Med fine
Color[b]	White	White	Any, except gray or blk	Gray	White	Gray
PHYSICAL PROPERTIES						
Specific Gravity	0.384	0.342	0.342	0.330	0.262	0.262
Operating Temp Range, F[c]	−80 to +200	−80 to +200	−80 to +200	−80 to +200	−80 to +200	−80 to +200
Ther Cond (70 F), Btu/hr/sq ft/°F/in.[d]	0.39	0.36	0.36	0.35	0.30	0.30
Coef of Ther Exp. per °F	0	0	0	0	0	0
Air Perm (1/16 in.), cfm/sq ft/0.5 in. H_2O	5–15	10–30	10–30	15–35	20–50	20–50
Liquid Absorption, %						
By Weight (1.0 sp gr liquid)	>125	>175	>175	>190	>250	>225
By Volume	71	74	74	76	80	80
Capillarity (wicking height, 575 SSU, 70 F), in.	4.5	4.0	4.0	4.0	3.0	3.0
Coef of Friction[e]	0.37	0.37	0.37	0.37	0.37	0.37
Vibration Absorption[f]						
Static Load Bearing Cap, per Unit Area	High	High	High	High	Medium	Medium
Dynamic Stress Endurance	High	High	High	High-med	High	High
Coef of Noise Reduction (1 in. thick)[d]	0.45	0.50	0.50	0.52	0.58	0.58
MECHANICAL PROPERTIES						
Ten Str (min), psi	600	500	500	400	400	275
Elong (at 100 psi), %	9	13	14	16	16	18
Mullen Burst Str (⅛ in. thick), psi	300	250	225	200	175	150
Split Res (min), lb/2-in. width	35	33	28	22	18	16
Hardness Range, Shore A	40–50	30–40	30–40	30–40	20–30	20–30
Compressibility (at 10% defl), psi	37	21	21	13	6	6
Recovery (within 1 min after 10% defl), %	99	99	99	99	99	99
Vibration Disintegration	None	None	None	None	None	None
Collapse When Wet	None	None	None	None	None	None
Abrasion Resistance[g]	Excellent	Excellent	Excellent	Excellent	Good	Good
Flexibility (fold endurance)	¼-in. thick felt exceeds 3 million 180° flexes					
CHEMICAL AND ENVIRONMENTAL PROPERTIES[h]						
Effect of Sunlight and Oxidation	None	None	None	None	None	None
Solvent Res, Stability in Oil	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Acid Resistance						
Dilute	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Concentrated	Good-fair	Good-fair	Good-fair	Good-fair	Good-fair	Good-fair
Alkali Resistance						
Dilute	Fair	Fair	Fair	Fair	Fair	Fair
Concentrated	Poor	Poor	Poor	Poor	Poor	Poor
FABRICATING METHODS	Can be fabricated by die-cutting, stripping, skiving; laminating, coating, impregnating; stitching, stapling, perforating, cementing; machining, grinding, drilling; and molding and shaping. All grades except 12R1 and 12R2 can be extruded					
TYPICAL USES	Bearing seals, ink rolls, polishing, printing, wick lubrication, and precision uses where dense high grade felt with max durability is required	Vibration mounts, precision channels, oil seals, bumpers, gaskets	Automotive, aircraft, machine components. Similar to 16R1 and 16R2, where lower density is acceptable	Lubricators, wipers, shock dampeners, etc., where durable resilient felt is required	Grease retainers, spacer strip seals, vibration mounts, weatherstrip, journal lubricators	

[a] Industrial, mechanical and filter felts; three dimensional fibrous structure.
[b] Colors available on special order. [c] Felts are flameproofed to meet government and industrial specifications.
[d] For 1-in. felts. Felts blended with kapok fiber have a k factor of 0.21 and a coefficient of sound absorption of 0.80 at 512 cps.
[e] Depends upon condition of contact surface, but can be moderately controlled by altering surface finish of the felt.
[f] Up to 85% under appropriate design conditions. [g] Increases with density. [h] Treated to resist moths, fungus, mildew and vermin.

Wool Felts—Roll[a]

Grade →	12R3	9R1	9R2	9R3	9R4	9R5
SAE Spec. No. →	F-7	F-10	F-11	F-12	F-13	F-15
GENERAL PROPERTIES						
Wool Content (fiber basis), min %	85	100	100	90	80	60
Standard Thickness Range, in.	⅛ to 1	⅛ to 1	⅛ to 1	⅛ to 1	⅛ to 1	⅛ to 1
Standard Width, in.	72	72	72	72	72	72
Texture	Medium	Fine	Med fine	Med fine	Medium	Medium
Color[b]	Gray	White	Gray	Gray	Gray	Gray
PHYSICAL PROPERTIES						
Specific Gravity	0.262	0.181	0.181	0.181	0.181	0.181
Operating Temp Range, F[c]	−80 to +200	−80 to +200	−80 to +200	−80 to +200	−80 to +200	−80 to +200
Ther Cond (70 F), Btu/hr/sq ft/°F/in.[d]	0.30	0.30	0.24	0.24	0.24	0.24
Coef of Ther Exp, per °F	0	0	0	0	0	0
Air Perm (1/16 in.), cfm/sq ft/0.5 in. H_2O	20–50	75–150	75–150	75–150	75–150	75–150
Liquid Absorption, %						
By Weight (1.0 sp gr liquid)	>225	>400	>375	>350	>350	>350
By Volume	80	88	88	88	88	88
Capillarity (wicking height, 575 SSU, 70 F), in.	3.0	2.5	2.5	2.5	2.5	2.5
Coef of Friction[e]	0.37	0.37	0.37	0.37	0.37	0.37
Vibration Absorption[f]						
Static Load Bearing Cap, per Unit Area	Medium	Low	Low	Low	Low	Low
Dynamic Stress Endurance	Medium	High	High-med	Medium	Low	Low
Coef of Noise Reduction (1 in. thick)	0.58	0.58	0.64	0.64	0.64	0.64
MECHANICAL PROPERTIES						
Ten Str (min), psi	250	225	200	100	75	75
Elong (at 100 psi), %	21	33	35	35	37	39
Mullen Burst Str (⅛ in. thick), psi	125	75	60	55	50	40
Split Res (min), lb/2-in. width	12	8	6	3	2	2
Hardness Range, Shore A	20–30	15–25	15–25	15–25	15–25	15–25
Compressibility (at 10% defl), psi	6	4	4	3	3	3
Recovery (within 1 min after 10% defl), %	99	99	99	99	99	99
Vibration Disintegration	None	None	None	None	None	None
Collapse When Wet	None	None	None	None	None	None
Abrasion Resistance[g]	Good	Fair	Fair	Fair	Fair	Fair
Flexibility (fold endurance)	¼-in. thick felt exceeds 3 million 180° flexes					
CHEMICAL AND ENVIRONMENTAL PROPERTIES[h]						
Effect of Sunlight and Oxidation	None	None	None	None	None	None
Solvent Res and Stability in Oil	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Acid Resistance						
Dilute	Good	Excellent	Excellent	Good	Fair	Fair
Concentrated	Fair	Fair-good	Fair-good	Fair-good	Fair	Fair
Alkali Resistance						
Dilute	Fair	Fair	Fair	Fair	Fair	Fair
Concentrated	Poor	Poor	Poor	Poor	Poor	Poor
FABRICATING METHODS	Can be fabricated by die-cutting, stripping, skiving; laminating, coating, impregnating; stitching, stapling, perforating, cementing; and molding and shaping. Grade 12R3 can also be machined, ground and drilled					
TYPICAL USES	Dust shields, oil and grease retainers; similar to 12R1 and 12R2 where a lower grade may be used	Fluid storage and delivery, resilient padding, plug filters for gas and air	Dryer drum seals, impregnated packing, insoles, insulation; oil, dust and mud shields	Chassis strips, spacers, dash liners, anti-squeak strips and pads, sound deadening	Grease and oil retention, protective lining and insulation for freight cars, trucks, dunnage; uses similar to 9R2 and 9R3 where less durability and lower grade felt is suitable	

[a] Notes on opposite page.

continued on next page

Wool Felts—Roll and Sheet[a]

Grade →	8R5	16R1X	16R3X	12R3X	32S1	32S2
SAE Spec. No. →	F-26	F-50	F-51	F-55	—	—
GENERAL PROPERTIES						
Wool Content (fiber basis), min %	50	100	100	80	100	100
Standard Thickness Range, in.	⅛ to 1	3/64 to 3/32	3/64 to 3/32	1/16 to 1/32	⅛ to 3	⅛ to 3
Standard Width, in.	72	60 or 72	60 or 72	60 or 72	36 x 36	36 x 36
Texture	Medium	Fine	Med fine	Medium	Extra fine	Fine
Color[b]	Gray	White	Gray	Gray or blk	White	White
PHYSICAL PROPERTIES						
Specific Gravity	0.154	0.330	0.330	0.256	0.682	0.682
Operating Temp Range, F[c]	−80 to +200	−80 to +200	−80 to +200	−80 to +200	−80 to +200	−80 to +200
Ther Cond (70 F), Btu/hr/sq ft/°F/in.[d]	0.25	0.32	0.32	0.30	0.91	0.91
Coef of Ther Exp, per °F	0	0	0	0	0	0
Air Perm (1/16 in.), cfm/sq ft/0.5 in. H_2O	100–200	15–25	15–40	20–50	<1	<1
Liquid Absorption, %						
By Weight (1.0 sp gr liquid)	>400	>180	>170	>225	>50	>50
By Volume	92	75	75	81	48	48
Capillarity (wicking height, 575 SSU, 70 F), in.	—	4.0	4.0	3.0	5.5	5.5
Coef of Friction[e]	0.37	0.37	0.37	0.37	0.42	0.42
Vibration Absorption[f]						
Static Load Bearing Cap, per Unit Area	Very low	—	—	—	Ultra high	Ultra high
Dynamic Stress Endurance	Very low	—	—	—	High	High
Coef of Noise Reduction (1 in. thick)[d]	0.65	0.55	0.55	0.58	0.05	0.05
MECHANICAL PROPERTIES						
Ten Str (min), psi	—	500	200	200	800	800
Elong (at 100 psi), %	—	8	9	25	2	2
Mullen Burst Str (⅛ in. thick), psi	25	225	225	200	Over 500	Over 500
Split Res (min), lb/2-in. width	—	—	—	—	50	48
Hardness Range, Shore A	5–15	—	—	—	75–85	75–85
Compressibility (at 10% defl), psi	1	—	—	—	121	121
Recovery (within 1 min after 10% defl), %	99	99	99	99	99	99
Vibration Disintegration	None	None	None	None	None	None
Collapse When Wet	Slight	None	None	None	None	None
Abrasion Resistance[g]	Poor	Excellent	Excellent	Good	Excellent	Excellent
Flexibility (fold endurance)	¼-in. thick felt exceeds 3 million 180° flexes					
CHEMICAL AND ENVIRONMENTAL PROPERTIES[h]						
Effect of Sunlight and Oxidation	None	None	None	None	None	None
Solvent Res and Stability in Oil	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Acid Resistance						
Dilute	Fair	Excellent	Excellent	Good	Excellent	Excellent
Concentrated	Poor	Fair-good	Fair-good	Fair	Fair-good	Fair-good
Alkali Resistance						
Dilute	Fair	Fair	Fair	Fair	Fair	Fair
Concentrated	Poor	Poor	Poor	Poor	Poor	Poor
FABRICATING METHODS	Can be fabricated by die-cutting, stripping, skiving; laminating, coating, impregnating; stitching, stapling, perforating, cementing; and molding and shaping. Grades 32S1 and 32S2 can also be machined, ground, drilled or extruded					
TYPICAL USES	Packing or padding when held between other materials; not recommended for mechanical use	Ball and roller bearing precision seals, strip wicks, industrial filters and uses requiring thin precision felt	Gaskets, liners, bearing seals, where precision tolerances, life and quality are not as exacting	Anti-squeak strips, anti-drumming and insulation lining cemented to metal or other type panels	Extra-hard density polishing wheels and buffs in dental jewelry, glass and lapidary polishing; also hard washers, bumpers and casters	

[a] Industrial, mechanical and filter felts; three dimensional fibrous structure.
[b] Colors available on special order. [c] Felts are flameproofed to meet government and industrial specifications.
[d] For 1-in. felts. Felts blended with kapok fiber have a k factor of 0.21 and a coefficient of sound absorption of 0.80 at 512 cps.
[e] Depends upon condition of contact surface, but can be moderately controlled by altering surface finish of the felt.
[f] Up to 85% under appropriate design conditions. [g] Increases with density. [h] Treated to resist moths, fungus, mildew and vermin.

Wool Felts—Sheet[a]

Grade →	32S3	32S4	26S1	26S2	26S3	26S4
GENERAL PROPERTIES						
Wool Content (fiber basis), min %	100	100	100	100	100	100
Standard Thickness Range, in.	⅛ to 3	⅛ to 3	⅛ to 3	⅛ to 3	⅛ to 3	⅛ to 3
Standard Width, in.	36 x 36	36 x 36	36 x 36	36 x 36	36 x 36	36 x 36
Texture	Medium	Coarse	Extra-fine	Fine	Med fine	Coarse
Color[b]	White	White	White	White	White	White
PHYSICAL PROPERTIES						
Specific Gravity	0.682	0.682	0.555	0.555	0.555	0.555
Operating Temp Range, F[c]	−80 to +200	−80 to +200	−80 to +200	−80 to +200	−80 to +200	−80 to +200
Ther Cond (70 F), Btu/hr/sq ft/°F/in.[d]	0.91	0.91	0.63	0.63	0.63	0.63
Coef of Ther Exp, per °F	0	0	0	0	0	0
Air Perm (1/16 in.), cfm/sq ft/0.5 in. H_2O	<1	<1	<3	<3	<5	<5
Liquid Absorption, %						
By Weight (1.0 sp gr liquid)	>50	>50	>75	>75	>75	>75
By Volume	48	48	58	58	58	58
Capillarity (wicking height, 575 SSU, 70 F), in.	5.5	5.5	5.0	5.0	5.0	5.0
Coef of Friction[e]	0.42	0.42	0.42	0.42	0.42	0.42
Vibration Absorption[f]						
Static Load Bearing Cap, per Unit Area	Ultra high	Ultra high	Very high	Very high	Very high	Very high
Dynamic Stress Endurance	Med-high	Medium	High	High	Med-high	Medium
Coef of Noise Reduction (1 in. thick)	0.05	0.05	0.28	0.28	0.28	0.28
MECHANICAL PROPERTIES						
Ten Str (min), psi	800	800	700	700	700	700
Elong (at 100 psi), %	2	2	4	4	4	4
Mullen Burst Str (⅛ in. thick), psi	>500	>500	>400	>400	>400	>400
Split Res (min), lb/2-in. width	46	40	48	46	40	30
Hardness Range, Shore A	75–85	75–85	55–65	55–65	55–65	55–65
Compressibility (at 10% defl), psi	121	121	86	86	86	86
Recovery (within 1 min after 10% defl), %	99	99	99	99	99	99
Vibration Disintegration	None	None	None	None	None	None
Collapse When Wet	None	None	None	None	None	None
Abrasion Resistance[g]	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Flexibility (fold endurance)	¼-in. thick felt exceeds 3 million 180° flexes					
CHEMICAL AND ENVIRONMENTAL PROPERTIES[h]						
Effect of Sunlight and Oxidation	None	None	None	None	None	None
Solvent Res and Stability in Oil	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Acid Resistance						
Dilute	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Concentrated	Fair-good	Fair-good	Fair-good	Fair-good	Fair-good	Fair-good
Alkali Resistance						
Dilute	Fair	Fair	Fair	Fair	Fair	Fair
Concentrated	Poor	Poor	Poor	Poor	Poor	Poor
FABRICATING METHODS	Die cutting, stripping, skiving; laminating, coating, impregnating; stitching, stapling, perforating, cementing; machining, grinding, drilling; molding and shaping; extruding					
TYPICAL USES	Similar to those indicated for 32S1 and 32S2	Hard-density wheels for polishing glass sheet, glassware, opthalmic lenses, metal and metallographic samples, wood and furniture; also block cutters, print rolls, cash carrier heads, marking pen nibs, casters, boot and shoe soles, artificial limbs				

[a] Notes on opposite page.

continued on next page

Wool Felts—Sheet[a]

Grade →	20S1	20S2	20S3	20S4	16S1	16S2
GENERAL PROPERTIES						
Wool Content (fiber basis), min %	100	100	100	100	100	100
Standard Thickness Range, in.	⅛ to 3	⅛ to 3	⅛ to 3	⅛ to 3	⅛ to 3	⅛ to 3
Standard Width, in.	36 x 36	36 x 36	36 x 36	36 x 36	36 x 36	36 x 36
Texture	Extra fine	Fine	Medium	Coarse	Extra fine	Fine
Color[b]	White	White	White	White	White	White
PHYSICAL PROPERTIES						
Specific Gravity	0.426	0.426	0.426	0.426	0.342	0.342
Operating Temp Range, F[c]	−80 to +200	−80 to +200	−80 to +200	−80 to +200	−80 to +200	−80 to +200
Ther Cond (70 F), Btu/hr/sq ft/°F/in.[d]	0.45	0.45	0.45	0.45	0.36	0.35
Coef of Ther Exp, per °F	0	0	0	0	0	0
Air Perm (1/16 in.), cfm/sq ft/0.5 in. H_2O	<10	<10	<15	<15	<20	<25
Liquid Absorption, %						
By Weight (1.0 sp gr liquid)	>100	>100	>100	>100	>175	>175
By Volume	66	66	66	66	74	74
Capillarity (wicking height, 575 SSU, 70 F), in.	4.5	4.5	4.5	4.5	4.0	4.0
Coef of Friction[e]	0.42	0.42	0.42	0.42	0.37	0.37
Vibration Absorption[f]						
Static Load Bearing Cap, per Unit Area	High	High	High	High	High	High
Dynamic Stress Endurance	High	High-med	Med-high	Medium	High	High-med
Coef of Noise Reduction (1 in. thick)[d]	0.41	0.41	0.41	0.41	0.50	0.50
MECHANICAL PROPERTIES						
Ten Str (min), psi	600	600	600	600	500	500
Elong (at 100 psi), %	9	9	9	9	12	12
Mullen Burst Str (⅛ in. thick), psi	325	325	325	325	250	250
Split Res (min), lb/2-in. width	44	40	36	32	32	28
Hardness Range, Shore A	45–55	45–55	45–55	45–55	30–40	30–40
Compressibility (at 10% defl), psi	58	58	58	58	32	32
Recovery (within 1 min after 10% defl), %	99	99	99	99	99	99
Vibration Disintegration	None	None	None	None	None	None
Collapse When Wet	None	None	None	None	None	None
Abrasion Resistance[g]	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Flexibility (fold endurance)	¼-in. thick felt exceeds 3 million 180° flexes					
CHEMICAL AND ENVIRONMENTAL PROPERTIES[h]						
Effect of Sunlight and Oxidation	None	None	None	None	None	None
Solvent Res and Stability in Oil	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Acid Resistance						
Dilute	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Concentrated	Good-fair	Good-fair	Good-fair	Good-fair	Good-fair	Good-fair
Alkali Resistance						
Dilute	Fair	Fair	Fair	Fair	Fair	Fair
Concentrated	Poor	Poor	Poor	Poor	Poor	Poor
FABRICATING METHODS	Die cutting, stripping, skiving; laminating, coating, impregnating; stitching, stapling, perforating, cementing; machining, grinding, drilling; molding and shaping; extruding					
TYPICAL USES	Medium-hard-density polishing wheels and buffs for polishing lenses, mirrors and glass, and marble and granite; fluid transfer rolls, ink rolls, furniture rubbing, rough metal polishing, metal wiping, drilled wicks, bearing seal washers, stamp pads, cushioning under sandpaper				Medium density polishing wheels and buffs for precious metals and plastics, rough optical polishing, metal wiping; drum beaters, drilled wicks, bearing seals, shoe rolls (shank), fluid transfer rolls, oil and fluid wicks, grease and oil retaining washers, ink rollers, vibration mounts, bumpers, plugs, glass channels	

[a] Industrial, mechanical and filter felts; three dimensional fibrous structure.
[b] Colors available on special order. [c] Felts are flameproofed to meet government and industrial specifications.
[d] For 1-in. felts. Felts blended with kapok fiber have a k factor of 0.21 and a coefficient of sound absorption of 0.80 at 512 cps.
[e] Depends upon condition of contact surface, but can be moderately controlled by altering surface finish of the felt.
[f] Up to 85% under appropriate design conditions. [g] Increases with density. [h] Treated to resist moths, fungus, mildew and vermin.

Wool Felts—Sheet[a]

Grade →	16S3	16S4	12S1	12S2	12S3	12S4
GENERAL PROPERTIES						
Wool Content (fiber basis), min %	100	100	100	100	100	100
Standard Thickness Range, in.	⅛ to 3	⅛ to 3	⅛ to 3	⅛ to 3	⅛ to 3	⅛ to 3
Standard Width, in.	36 x 36	36 x 36	36 x 36	36 x 36	36 x 36	36 x 36
Texture	Medium	Coarse	Extra fine	Fine	Medium	Coarse
Color[b]	White	White	White	White	White	White
PHYSICAL PROPERTIES						
Specific Gravity	0.342	0.342	0.256	0.256	0.256	0.256
Operating Temp Range, F[c]	−80 to +200	−80 to +200	−80 to +200	−80 to +200	−80 to +200	−80 to +200
Ther Cond (70 F), Btu/hr/sq ft/°F/in.[d]	0.36	0.36	0.30	0.30	0.30	0.30
Coef of Ther Exp, per °F	0	0	0	0	0	0
Air Perm (1/16 in.), cfm/sq ft/0.5 in. H_2O	<30	<35	<30	<40	<50	<60
Liquid Absorption, %						
By Weight (1.0 sp gr liquid)	>175	>175	>250	>250	>250	>250
By Volume	74	74	81	81	81	81
Capillarity (wicking height, 575 SSU, 70 F), in.	4.0	4.0	3.0	3.0	3.0	3.0
Coef of Friction[e]	0.37	0.37	0.37	0.37	0.37	0.37
Vibration Absorption[f]						
Static Load Bearing Cap, per Unit Area	High	High	Medium	Medium	Medium	Medium
Dynamic Stress Endurance	Med-high	Medium	High	High-med	Med-high	Medium
Coef of Noise Reduction (1 in. thick)	0.50	0.50	0.58	0.58	0.58	0.58
MECHANICAL PROPERTIES						
Ten Str (min), psi	500	500	400	400	400	400
Elong (at 100 psi), %	12	12	28	28	28	28
Mullen Burst Str (⅛ in. thick), psi	250	250	150	150	150	150
Split Res (min), lb/2-in. width	22	20	18	16	12	10
Hardness Range, Shore A	30–40	30–40	20–30	20–30	20–30	20–30
Compressibility (at 10% defl), psi	32	32	18	18	18	18
Recovery (within 1 min after 10% defl), %	99	99	99	99	99	99
Vibration Disintegration	None	None	None	None	None	None
Collapse When Wet	None	None	None	None	None	None
Abrasion Resistance[g]	Excellent	Excellent	Good	Good	Good	Good
Flexibility (fold endurance)	¼-in. thick felt exceeds 3 million 180° flexes					
CHEMICAL AND ENVIRONMENTAL PROPERTIES[h]						
Effect of Sunlight and Oxidation	None	None	None	None	None	None
Solvent Res and Stability in Oil	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Acid Resistance						
Dilute	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Concentrated	Good-fair	Good-fair	Good-fair	Good-fair	Good-fair	Good-fair
Alkali Resistance						
Dilute	Fair	Fair	Fair	Fair	Fair	Fair
Concentrated	Poor	Poor	Poor	Poor	Poor	Poor
FABRICATING METHODS	Die cutting, stripping, skiving; laminating, coating, impregnating; stitching, stapling, perforating, cementing; machining, grinding, drilling; molding and shaping; extruding					
TYPICAL USES	Medium density polishing wheels and buffs for precious metals and plastics, rough optical polishing, metal wiping; also drum beaters, drilled wicks, bearing seals, shoe rolls (shank), fluid transfer rolls, oil and fluid wicks, grease and oil retaining washers, ink rollers, vibration mounts, bumpers, plugs, glass channels		Soft density polishing wheels and buffs for polishing plastics, and polishing and wiping brass; also piano wedges, surgical pads, punched wicks, dampeners, absorbent pads, oil and fluid retainers, fluid transfer rolls, bearing seals, washers, wicks, shim and spacer pads, shoe insoles, dust shields			

[a] Notes on opposite page.

KENNAMETAL

HARD CARBIDE ALLOYS AND METALLURGICAL PRODUCTS

PRODUCTS	PROPERTIES	TYPICAL APPLICATIONS
Kennametal (tungsten-base carbides)	YME of 60 to 90 million psi. Compressive strength higher than virtually all melted and cast or forged metals and alloys. Kennametal outwears steel up to 100 to 1. Impact strength in the range of hardened alloy steels of very much lower hardness and compressive strength. Thermal expansion about half that of steel. Compositions to withstand one or various combinations of destructive agents such as abrasion, corrosion, galling, impact, and erosion, or meet specific requirements as to stiffness, strength and weight.	Metalworking and mining tool cutting edges. Die inserts. Seal rings. Integrator discs. Needle valves and cones. Compressor liners. Pulverizing hammers. Abrasion resistant knives, blades, shears. Boring bars. Spray orifices. Balls and seats for oil well pump valves.
Kentanium* (titanium-base carbides)	Superior strength and abrasion resistance at temperatures 1800°F. and up . . . temperatures that rapidly destroy conventional carbides or high temperature cast alloys. Can be subjected continuously to operating temperatures up to 2200°F., and up to 5000°F. for short periods. Greater resistance to thermal shock than ceramics. Highest stiffness-to-weight ratio of any material . . . approximately ⅗ the weight of steel. YME up to 60 million psi.	Sensing elements for high temperature thermostatic controls. Spinning tools for hot metals. Flash-trimming tools. Turbine components. Balls for pump check valves. Nuclear reactor equipment. Rotary seal rings. Hot rod mill guide inserts. Anvils for spot welding. Balls for hot hardness testing.
Refractory Carbides	High purity. High melting point—5000°F. to 7000°F.	In powder form as basic materials. Acid resistant parts and crucibles. High temperature furnace parts.
Heavy Tungsten Alloys	Nominal Density: 16.5 to 18.7 gm/cc. Machinability? Good. Tensile Strength: 40,000 to 90,000 psi. Corrosion Resistance: Excellent. Readily brazed with Easy-Flo No. 3 Compound. Available as bars, rods, rings, discs, special shapes.	Counterweights. Radioactive shielding. Isotope containers. Atomic watch shielding. Shielding—cobalt and X-ray medical equipment. Rotational parts—flywheels, governors, gyroscope components. Electrical contactors for high current, heavy duty applications.
Niobium	Metal—99.8% grade. Granules, arc melting electrodes, bar, strip. Metal—99.5% and technical grades. Powders, granules, arc melting electrodes. Oxide—99% and 99.5% grades. Fine powder.	Arc melting electrodes: Nominal size 1″ x 2″ x 20″. Niobium-base alloy electrodes also available. Powders: 20 to 80 mesh. Granules: 3/16″ to 40 mesh.
Tantalum	Metal—99.9% (capacitor) grade. Solid form—strip, bar, wire. Metal—99.5% grade. Granules. Metal Powder—99.8% grade. Fine powder. Oxide—99% grade. Fine powder.	Anodes: Sintered for both liquid and solid electrolytic capacitors, wide range of sizes. Strip: .001″ to .100″ thick, up to 12″ wide. Wire: From .005″ to .030″. Powder: 200 mesh. Other sizes available. Oxides: In analyses and particle sizes to meet specific requirements.

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2. **Kentanium**—12-page description of physical characteristics and applications.
3. **Designing with Kennametal**—42 pages of design ideas . . . problems and solutions in designing with carbides, fastening methods, typical applications.
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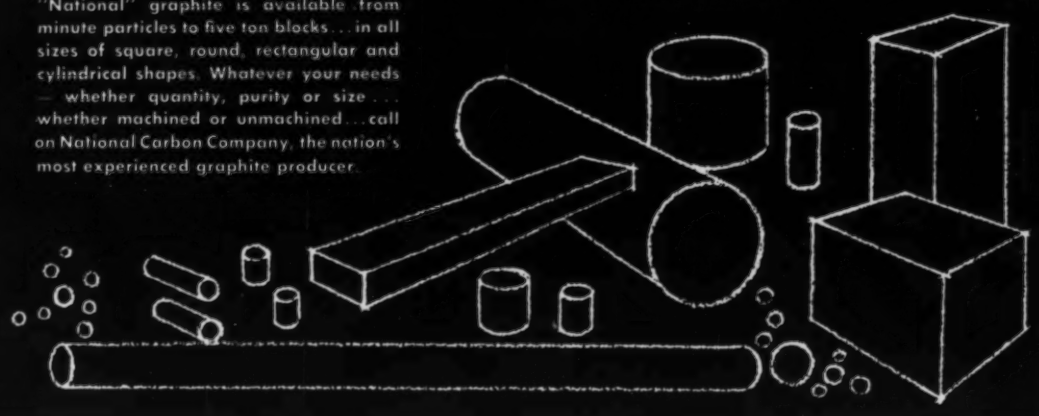

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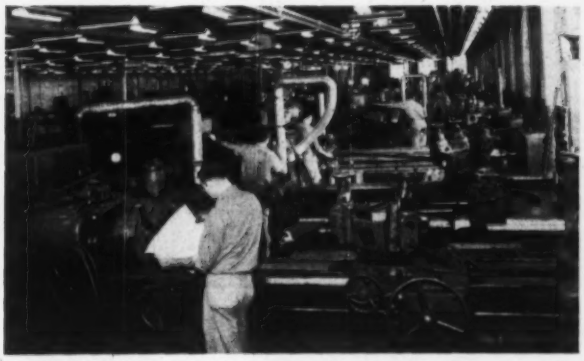

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UNION CARBIDE

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Physical Properties of McDANEL Industrial Ceramics

FIRED PROPERTIES	Pure Alumina 99% Al_2O_3	Pure Alumina 99% Al_2O_3	Vitreous Alumina 96% Al_2O_3	Vitreous Alumina 85% Al_2O_3	Crushable Alumina	Vitreous Refractory Mullite	Vitreous Refractory Mullite	Vitreous Refractory Mullite
BODY NUMBER	**AP30**	**AP35**	**AV30**	**AV20**	**CA**	**MV33**	**MV30**	**MV20**
Water Absorption %	12.9	0.00	0.00	0.00	13.5	0.00	0.00	0.00
Specific Gravity	2.6	3.7	3.5	3.2		3.3	3.2	3.0
Gas Permeability R.T. Temperature to which 10^{-5} mm Hg will maintain	Porous	Impervious 1500° C 2732° F	Impervious 1450° C 2642° F	Impervious	Porous	Impervious 1500° C 2732° F	Impervious 1450° C 2642° F	Impervious
Compressive Strength psi		250,000	250,000	150,000		150,000	120,000	100,000
Tensile Strength psi		35,000	35,000	20,000		18,000	18,000	14,000
Transverse Strength psi		45,000	45,000	30,000		22,000	20,000	20,000
Coefficient of Linear Thermal Expansion /° C /° F	7.8×10^{-6} 4.3×10^{-6}	7.8×10^{-6} 4.3×10^{-6}	7.8×10^{-6} 4.3×10^{-6}	7.2×10^{-6} 4.0×10^{-6}		4.8×10^{-6} 2.7×10^{-6}	5.4×10^{-6} 3.0×10^{-6}	5.0×10^{-6} 2.8×10^{-6}
Approximate Thermal Conductivity cal/sec/cm^2/cm/° C Btu/hr/ft^2/in/° F	.040 116.	.050 145.	.050 145.	.040 116.		.006 17.4	.006 17.4	.005 14.5
Maximum Service Temperature ° C ° F	1900° C 3452° F	1900° C 3452° F	1650° C 3002° F	1520° C 2768° F	1650° C 3002° F	1760° C 3200° F	1650° C 3002° F	1650° C 3002° F
Dielectric Constant 1MC		9.0	8.5	8.5		7.0	7.0	6.5
Dielectric Strength volts/mil ¼" thickness		400	350	300		300	300	300
Volume Resistivity Ohm cm. Room Temp. 700° C		10^{15} 10^{8}	10^{15} 10^{8}	10^{15} 10^{7}	10^{14} 10^{6}	10^{15} 10^{6}	10^{15} 10^{6}	10^{14}
Te Value ° C ° F	800° C 1472° F	800° C 1472° F	800° C 1472° F	800° C 1472° F	800° C 1472° F	800° C 1472° F	700° C 1292° F	700° C 1292° F
Hardness (Mohs Scale)		9	9	8½	Chalky	8	7½-8	
Fabrication Methods	Cast Dry Press Extrusion	Cast Dry Press Extrusion	Cast Dry Press Extrusion	Dry Press Extrusion	Extrusion	Cast Extrusion	Cast	Dry Press Extrusion
Comments D660	Fine grain material. Use above 1650°C will result in additional shrinkage.	Recrystalized Alumina, our most refractory material. Excellent deformation resistance. Superior resistance to reducing atmospheres and chemical reaction at high temperatures.	Recrystalized Alumina. Low loss, high dielectric for normal and high temperatures. High strength with excellent resistance to abrasion, chemical attack and reducing atmosphere.	Good abrasion resistance and electrical properties for lower temperature use.	Soft bonded insulation for swaged thermocouples. Non-hygroscopic.	Stoichiometric Mullite similar to MV30 but with little or no free silica. Exceptional deformation resistance at elevated temperatures.	Good chemical and atmosphere resistance at elevated temps. Excellent thermal shock and sag resistance.	Similar to MV30 but somewhat lower in all physical properties.

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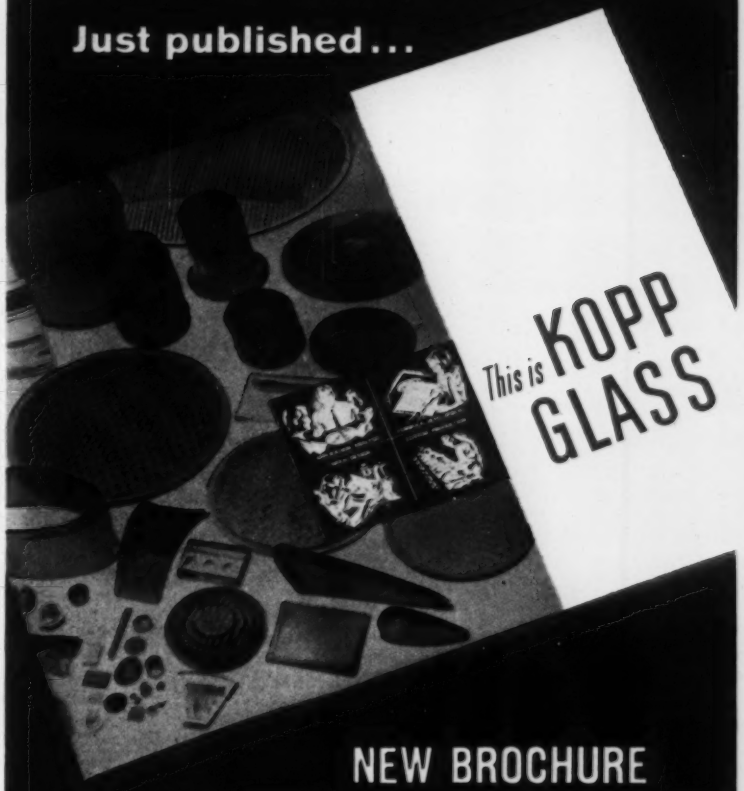

NEW BROCHURE shows how Glass can be engineered to solve specific design problems

Twenty colorful pages describe the Kopp Glass engineering service; showing how the properties of glass are controlled and combined to provide designers and manufacturers with specialized, custom-produced products that meet specific application requirements. This includes analyzing the application, developing the formula, designing the mold and establishing manufacturing procedures.

A few examples shown in the book include street and highway traffic control lenses; aviation, marine and railroad signaling lenses; dental and surgical lighting filters; street and interior lighting glassware; floodlight cover glasses; industrial globes and indicator lenses; theatrical and exterior lighting color filters.

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KOPP GLASS

Kopp Glass, Inc. MDE
Swissvale, Pa.

Please send copy of "This is Kopp Glass"

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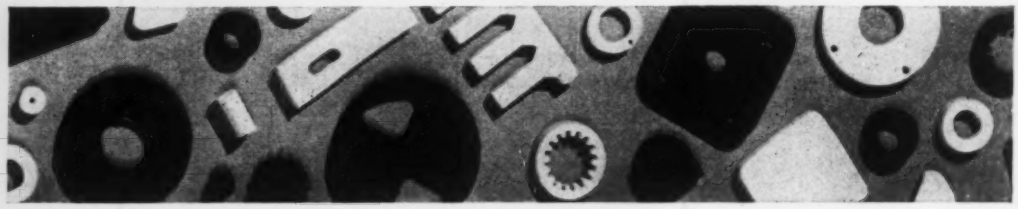
Kopp Glass, INC.
Swissvale, Pennsylvania
MANUFACTURERS OF MOLDED INDUSTRIAL AND SIGNAL GLASSWARE

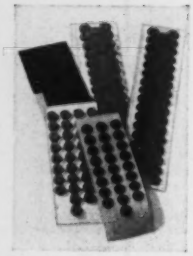
For more information, turn to Reader Service card, circle No. 545



Can these **FELT IDEAS** help you?

FELT GREATLY REDUCES GLAZING COSTS

over conventional brushing. Fine china manufacturer uses special Felters DuFelt Polishing Belt to reduce glazing costs. Felt coarseness and density can be varied for most effective polishing of metal, glass and ceramics. Can also be coated with abrasives.



FELT ADHESIVE TAPES AND PADS

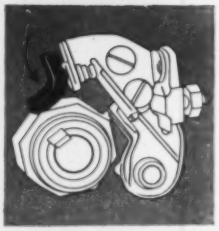
are the most inexpensive material for sealing, padding and cushioning. Felt strips seal out dust, dirt, wind, fumes, moisture, and eliminate squeaks and rattles.

FELT AS A LOW COST FRICTION MATERIAL

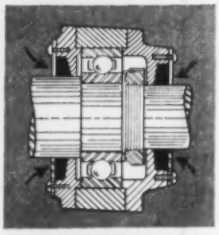
Used as a braking or friction device, sometimes combined as a seal or washer. High coefficient of friction and extra density provide foolproof clutching and tension action at low cost, like the Lever Puller shown at left.

To get the most out of Felt, send for the Felters Design Book — a complete digest on properties and applications. Write, today.

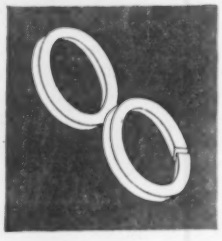
DuFelt is a laminated combination of Felters' felt and Hycar; and is recommended for sealing of lighter oils when no head exists. Seals and lubricates at the same time; and offers improvements over other materials.



Felt is an ideal wicking and lubricating material which can be designed into special assemblies like this distributor cam shown here. Lubrication is constant, wear reduced, and felt can be shaped to cover all required areas.



Lifetime bearing lubrication is now possible by selection of correct SAE grade, and designing into sealed bearing. Felt filters out contamination and works as combined reservoir and wick, directing oil flow to required areas.



Mechanical felt seals permit a close seal without undue pressure. Felt can be waterproofed and provides superior grease and oil retaining and dust, dirt and grit exclusion.

Ask for **FELT** *from . . .*

THE FELTERS COMPANY

220 SOUTH STREET, BOSTON 11, MASSACHUSETTS

Pioneer Producers of Felt and Synthetic Non-Woven Fabrics

FEO-58

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YOU CAN GET better laminated and molded products three ways with Pittsburgh Fiber Glass. ○ *First*—PPG provides you with a quality, uniform reinforcement of exceptional dimensional stability and dielectric strength; it's fire-resistant, heat-resistant, odorless. ○ *Second*—PPG can supply you with quality YARNS in any twist or ply, in all standard sizes . . . ROVING in a variety of finishes and end counts wound to your requirements; it's static-free, ideal for use in preforming or spraying . . . CHOPPED STRAND in lengths of ¼" and up, packaged for convenient handling; its uniformity helps cut rejects. ○ *Third*—PPG offers you technical help through free trials made in your own plant to show you how Pittsburgh Fiber Glass can help you produce better end products. Call your nearest PPG Sales Office or write Pittsburgh Plate Glass Company, Fiber Glass Division, One Gateway Center, Pittsburgh 22, Pa.

Sales Offices: Atlanta, Boston, Buffalo, Charlotte, Chicago, Cincinnati, Cleveland, Dallas, Denver, Detroit, Fort Wayne, Houston, Jacksonville, Kansas City, Los Angeles, Louisville, Milwaukee, Minneapolis, New Orleans, New York, Philadelphia, Pittsburgh, St. Louis, San Francisco, Seattle and Washington.

FIBER PPG GLASS PITTSBURGH PLATE GLASS COMPANY

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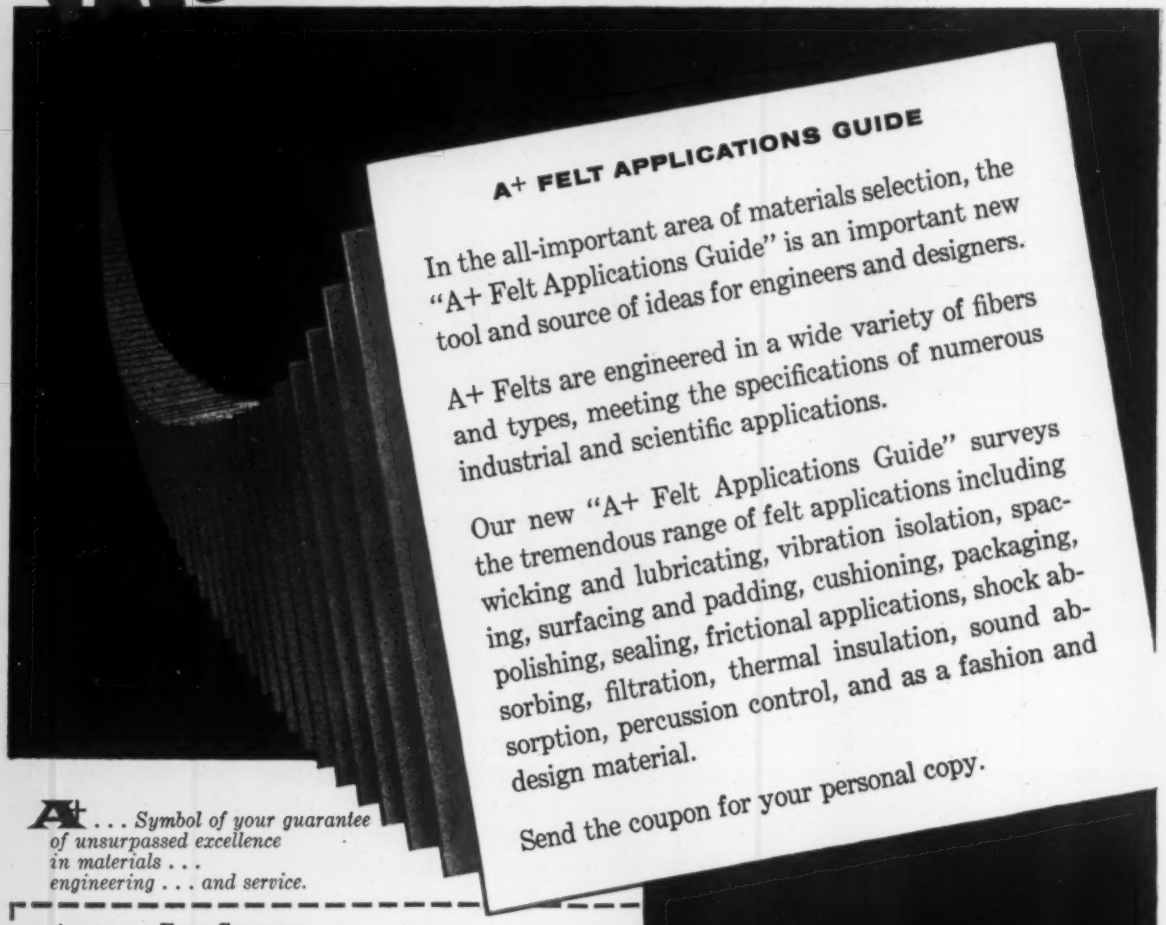
FOR YOUR REFERENCE



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POSITION.....
STREET.....
CITY.....ZONE.....STATE.....

American Felt Company

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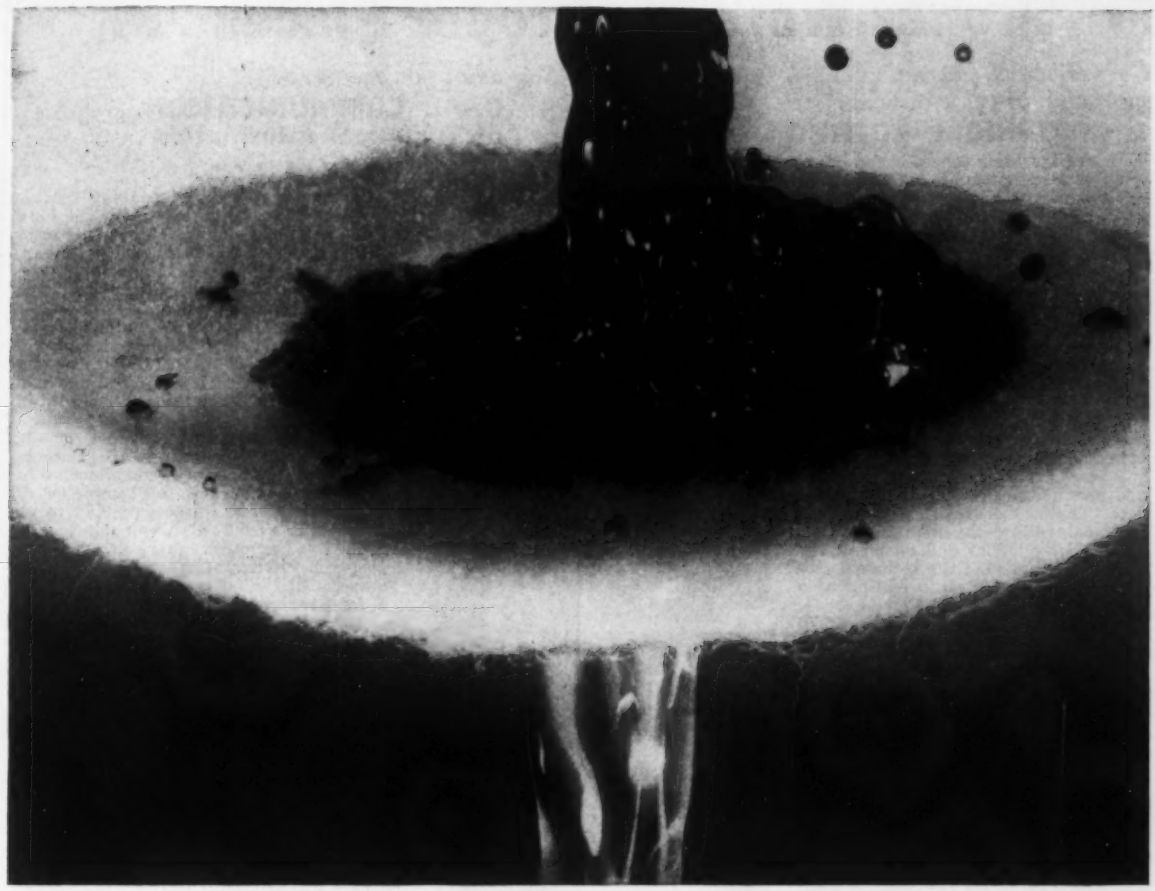
An example of Avisco Rayons in Industry



Why rayon fibers are rapidly gaining in filtration applications

Avisco rayon fibers have been making giant strides in filters for smoke, air and liquid filtration. Why? Because they can be engineered to meet specific filtration needs . . . plus low cost and filtration control.

Avisco rayon can be produced in accurate diameters resulting in controlled micron ratings economically unapproached by other fibers.

American Viscose makes the fibers, not the filters. If you make or use filters, it will pay you to investigate Avisco fibers for more accurate, more economical filtration. *Just fill in the Quick Reply Coupon.*

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AMERICAN VISCOSE CORPORATION, 350 Fifth Avenue, New York 1, N. Y.

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Proper Words in Proper Places . . .

Covers books, journals, manuals, graphic aids . . .

1 TECHNICAL EDITING

Edited by
B. H. WEIL
Chief Editor, Technical Information Division
Esso Research and Engineering Company

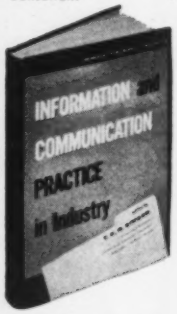
Here are the basic concepts and operating practices of internal communications, journal editing, book publishing, and graphic aids presentation for all technical fields. The contributors are leading authorities, and they provide ideal guidance for both the experienced and beginning editor. This book is much more than a copyreading manual; it deals with editing as a primary communications step. It relates the documents of all technical areas to the cardinal purpose of serving the potential reader. There is also emphasis on how to work with authors. This is the first time that every technical editing principle has been brought together in one place. The coverage of subjects and techniques is thoroughly up-to-date. The book serves the experienced technical editor, the management of technical industries and agencies, the fledgling editor, and the technical student who is attracted to editing as a profession.

1958, 288 pages, $5.75

Do it right the first time . . .

2 INFORMATION AND COMMUNICATION PRACTICE IN INDUSTRY

Edited by
T. E. R. SINGER
Technical Information Consultant



Immediate answers to every communication question are clearly provided here in the best handbook style. Nineteen chapters cover the entire subject for technical organizations of all kinds. Several leading experts contribute valuable directions for the most efficient handling and transmission of data, information and ideas. Whether you want to design data tables, classify material, edit a report, or abstract articles—this is the one book that shows you how to accomplish the numerous tasks involved with modern communications. By the very nature of its material, it also provides ideas and suggestions for improving company or institutional communications programs.

1958, 310 pages, $8.75

Write what you mean . . .

3 BETTER REPORT WRITING

by WILLIS H. WALDO
Technical Editor, Research Dept.
Organic Chemicals Div., Monsanto Chemical Co., St. Louis, Mo.

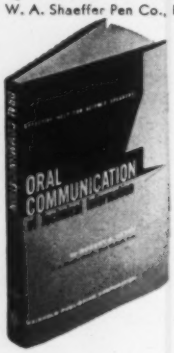
Here is fingertip help with the chronic problems of scientific expression for all technical report writers. This handy desk guide presents authoritative facts on the important details of effective scientific composition, style, division of reports, tables, illustrations, and use of words. The book is purposely written as a quick reference instead of a classical exposition of technical English. It simplifies the solution of writing problems for all technical authors. Three appendices condense a vast amount of information on abbreviations, symbols and hyphenation. This is the first easily readable guide in book form for the practicing report writer. Whatever field of technical endeavor you're reporting, this handbook contains much profitable information for you.

1957, 239 pages, $4.75

Say what you mean . . .

4 ORAL COMMUNICATION of Technical Information

by ROBERT S. CASEY
W. A. Shaeffer Pen Co., Fort Madison, Iowa



Methods of effective speaking for almost all situations are assembled here in "how-to" manner for technical men. Beginning with the bridges and barriers to effective communication, the book then takes up the actual problems involved and how they are solved. It covers organization of material, composition, delivery of formal and impromptu speeches, and the use of mechanical aids such as recordings and slides. How to preside at meetings, talk science to laymen, give technical legal testimony, and converse socially are covered in helpful detail. Emphasis is on the special needs of technical subject matter, but the techniques of organization and delivery apply to all speaking events. One valuable section reviews the most common errors in the speech-writing of chemists and engineers. It is doubtful that a more useful handbook for speakers in the technical field has ever been published.

1958, 207 pages, $4.50

Quick, convenient guide to thousands of difficult technical words . . .

5 HAWLEY'S TECHNICAL SPELLER

by GESSNER G. HAWLEY
Executive Editor, Reinhold Book Division
and ALICE W. HAWLEY
Consulting Editor

Contained in this handy book is a wide selection of technical words used in the fields of chemistry, physics, electronics, engineering, biology and medicine. Also included are many common words of troublesome spelling which repeatedly occur in technical writing and correspondence. Many of these words, such as names of complex chemicals and proper names, do not appear in desk-size dictionaries. Recommended word divisions are indicated, and easily confused meanings or spellings are explained in footnotes. Writers of technical letters and reports, advertising copy, scientific articles and books will want this quick-reference guide constantly within handy reach. Secretaries who take technical dictation or transcribe manuscripts will find it a wonderful time-saver.

1955, 160 pages, $2.95

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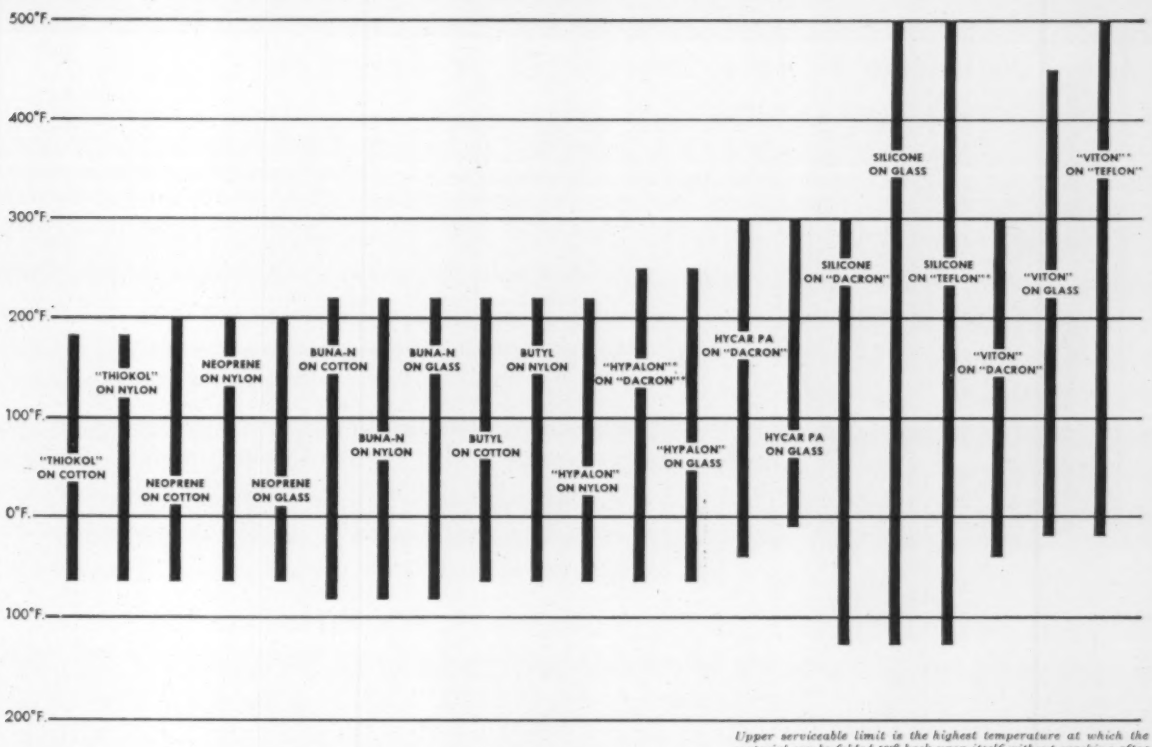

Upper serviceable limit is the highest temperature at which the material can be folded 180° back upon itself without cracking after 72 hours' exposure. Low limit is the lowest temperature at which the material can be bent around a 1" mandrel after 1 hour's exposure.

Temperature effects on the serviceability of Du Pont Fairprene®

Charted above are the serviceable temperature ranges for many of Du Pont's "Fairprene"* coated fabrics. These materials form design materials of amazing versatility with an outstanding range of lubricant, solvent, flex, ozone, age and chemical resistance as well as thermal stability.

Du Pont engineers are eager to help you evaluate "Fairprene" for designing new products or improving old ones. These versatile materials are now being used in hundreds of applications ranging from fire walls to gaskets and diaphragms. For full information and your free copy of Du Pont's coated fabrics manual, mail coupon or write: E. I. du Pont de Nemours & Co. (Inc.), Fabrics Division MD-011, Wilmington 98, Delaware.

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12-page booklet describes in detail all basic specifications, properties, uses and performance characteristics for "Fairprene"* coated fabrics and cements. Mail coupon or write Du Pont . . . there's no obligation.

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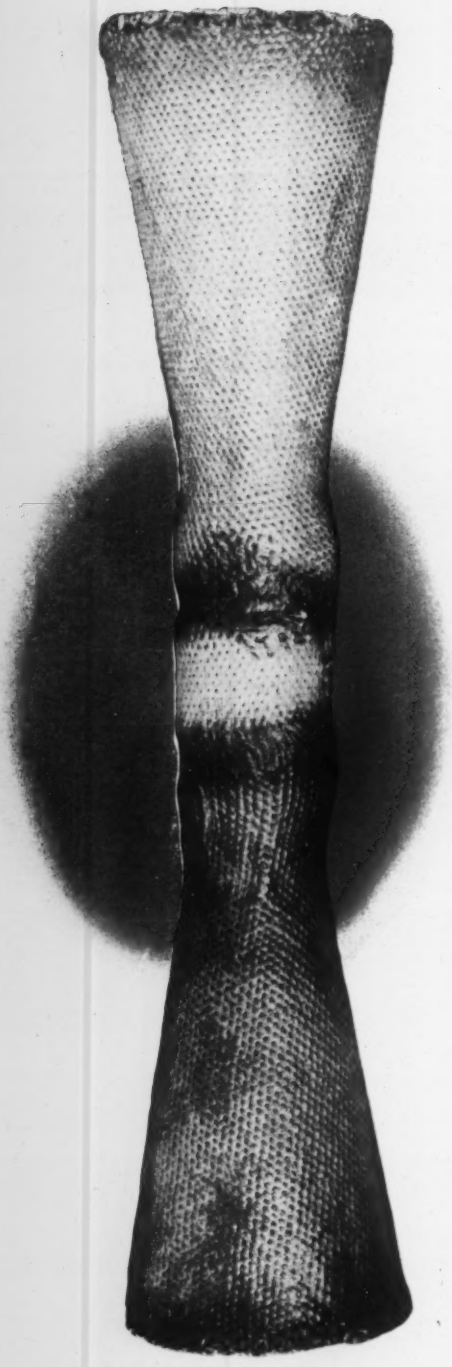
Let Your Creative Imagination Go to Work on These

NEW DEVELOPMENTS



Chrysotile asbestos, one of the most versatile and economical fibrous materials available today, is steadily increasing its value as an engineering material. In addition to being less expensive than other fibrous reinforcing materials and in abundant supply, chrysotile asbestos outperforms all known fibrous materials when the following combination of characteristics is needed:

- HEAT RESISTANCE
- WEATHER RESISTANCE
- MOISTURE RESISTANCE
- ABRASION RESISTANCE
- HIGH TENSILE STRENGTH
- FREEZE AND THAW RESISTANCE

For your information, Lake Asbestos of Quebec reports here two new developments which demonstrate the versatility of chrysotile fiber as a reinforcing design material.

Cerbestos: For Continuous High Temperature Applications

One of the most promising new products from chrysotile fiber is Cerbestos, a combination of asbestos cloth and ceramic clay with all the advantages of both. Asbestos cloth provides the required strength, heat resistance and flexibility. Kaolin clay adds refractory properties and rigidity. Result: a new material with remarkably high thermal and mechanical stability.

Cerbestos has successfully withstood a temperature of 2500°F continuously for seven days. During a recent oxygen-acetylene burn-through test, a four-layer mat of Cerbestos withstood direct-torch heat 37½ times longer than stainless steel. Cerbestos is being evaluated for a number of missile and space probe applications, such as instrument shielding and rocket discharge tubes.

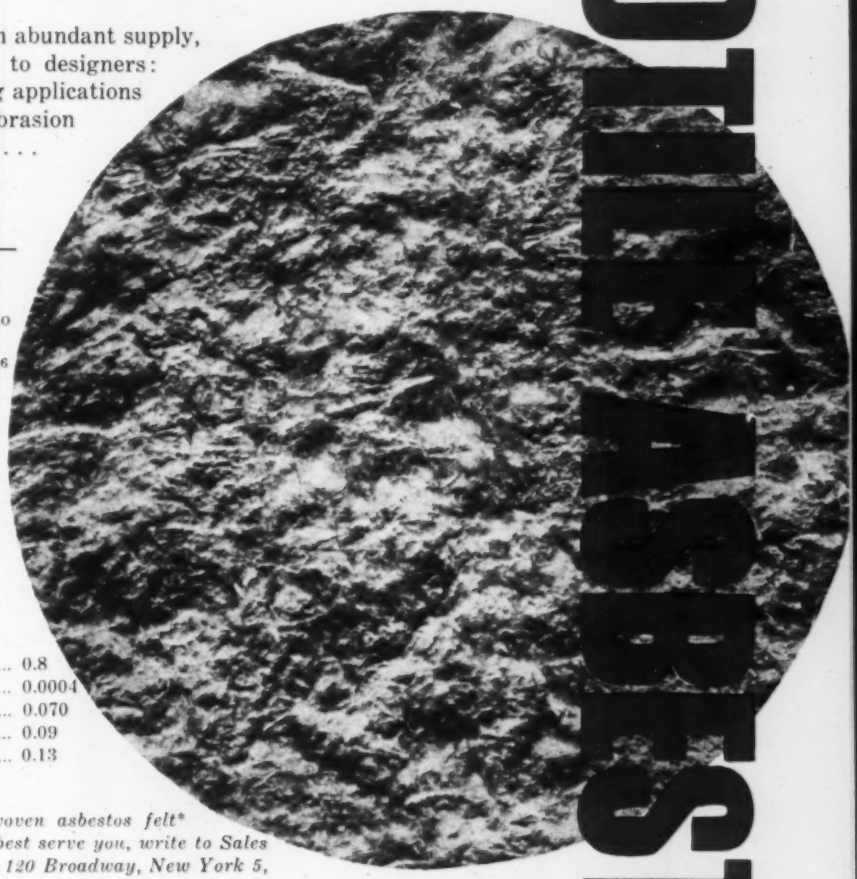
Cerbestos is an economical material easily formed into desired shapes for the most intricate applications. Explore its design possibilities for your products — old or new.

IN ASBESTOS

Asbestos Fiber in Non-Woven Form

The unique properties of chrysotile — fibrous form, tensile strength, fine diameter, flexibility, and resistance to heat, moisture and weathering — are combined in a new non-woven felt which is being used as the basic reinforcement for consumer products — chairs, tables, boats — for defense equipment, missile and space probe nose cones and other high temperature components. Asbestos felt, formed in continuous lengths in widths up to four feet, can be used as replacement for or in combination with glass fiber.

Less expensive than glass fiber and in abundant supply, non-woven asbestos felt means this to designers: A new inorganic fiber for reinforcing applications . . . superior strength, flexibility, abrasion resistance . . . better natural bonding . . . substantially lower production and end-product costs . . . greater design freedom.



PHYSICAL CONSTANTS
of Chrysotile Asbestos

Tensile Strength — psi	300,000 to 400,000
Modulus of Elasticity — psi	26.5×10^6
Fusion Point — °F	2770
Max. Ignition Loss Temp. — °F	1800
Specific Heat — BTU/lb./°F	0.266
pH	8.6
Surface Area — Sq. meters/gr.	10
Electrical Charge	Pos.
Finite Fiber Diameter — 180 Angstroms = 0.000000706"	

CHEMICAL DATA

Typical Chemical Analysis of ASARCO Asbestos (percent by weight)

MgO	40.5	CO_2	0.8
SiO_2	39.0	Cu	0.0004
Al_2O_3	0.6	Mn	0.070
Total Iron as Fe	3.2	Cr	0.09
CaO	<0.1	Ni	0.13

Ign. loss at 1800°F 14.2

For additional information about non-woven asbestos felt and Cerbestos* and how asbestos can best serve you, write to Sales Department, Lake Asbestos of Quebec, Ltd., 120 Broadway, New York 5, N. Y., or call REctor 2-9500.*

* Not produced by Lake Asbestos

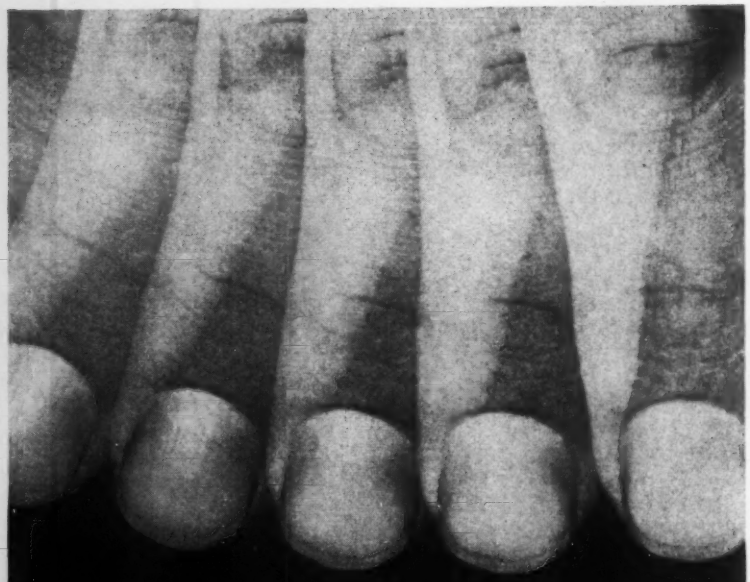
LAKE ASBESTOS OF QUEBEC, LTD.

A subsidiary of American Smelting and Refining Company

ASARCO

CHRYSOTILE ASBESTOS

If your design includes a coated fabric... choose



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The most complete source of coated fabrics for industry

When your design calls for diaphragms, seals, gaskets, vapor barriers... any of the hundreds of coated fabric applications... look to the most complete source in the field—the Reevecote line of industrial coated fabrics.

With natural and synthetic rubber coatings, Reevecote is available in over 200 styles—also uncured for molding.

Whether its resistance to oil, acids, abrasion, high temperature ... or flexibility at low temperatures... there's a Reevecote fabric designed and engineered to do the job right.

Continuous research and development enables Reeves to keep pace with *all* your needs for coated fabrics. And our rigid quality control guarantees that Reevecote fabrics will always meet established specifications.

Make your choice now! Write for new Reevecote catalog today.

REEVES VULCAN

Reeves Brothers, Inc., Vulcan Rubber Products Division
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where contamination must be avoided

SPECIFY SPEER ULTRA PURE GRAPHITE

You can eliminate undesirable contamination of many metals and crystals by using crucibles, boats and jigs made of SPEER Ultra Pure Graphite. Parts for electronic tubes and mercury-arc rectifiers may also be improved by the higher degree of purity now offered in this material.

A typical sample of SPEER Ultra Pure Graphite would contain—

B	.25 ppm
Fe	1.0 ppm
V	1.0 ppm

and—especially important in certain usages such as vacuum tubes—would show gas content of .2 to .5 cm^3/gm. This is less gas than is contained in corresponding unpurified grades.

What is your application? SPEER molded and extruded Ultra Pure Graphite is available in many grades and in sizes ranging to more than 16" diameter. We are also prepared to machine parts and equipment expertly to your own close tolerances. *Our engineers will be glad to discuss your specific problems with you.*

SPEER Carbon Co

CARBON PRODUCTS DIVISION
ST. MARYS, PENNSYLVANIA

For more information, circle No. 560

Why it will pay you to

CONSIDER GLASS

before your products reach the blueprint stage

WHY GLASS?

It's versatile and basic.

And if it is a *Corning* glass, it offers your products these solid benefits:

Permanent finish. Corning glass compositions resist weather, chemical attack, abrasion and high temperatures. Their surfaces stay non-absorbent and non-porous — clean quickly.

Controlled transparency. Corning glasses are uniformly transparent—piece after piece, year after year. Colored or clear—they never lose their original clarity.

Hermetic enclosures can be made in rugged designs from special glasses developed for glass-to-metal fusion sealing.

Electrically conductive coatings. Fired on to glass, they are a very efficient source of radiant energy. They provide uniform heat distribution of a long wave length radiation readily absorbed by most materials.

Durability. Glasses with ingenious balances of mechanical, electrical and chemical properties plus correlation of form and shape insure a durable product.

Heat indifference. Corning glass keeps strength and finish at high temperatures—in some compositions from 900°F. to 1700°F. Heat indifference is furthered by designs that carefully distribute thermal stress.

Electrical stability. Corning glasses have high resistivity, low power losses, low and high dielectric constants, excellent non-tracking properties. They can also be furnished with special characteristics of high dielectric strength.

Chemical inertness. Corning glasses resist most atmospheres and chemicals even at relatively high temperatures—do not pit, scale or rust. They keep their chemical, mechanical and electrical properties indefinitely.

WHICH GLASS?

You can choose from five types of Corning glasses. These fill most needs. But, if you have an unusual application—one that cannot be met by any of the following types—special variations will be suggested.

Borosilicate glasses have high thermal endurance, softening points, chemical resistance, and excellent electrical stability.

High silica glasses have extreme thermal endurance, very high softening point, high chemical resistance, excellent electrical properties, and exceptional transmittance of the ultraviolet or the infrared.

Opal glasses have uniform and well-controlled translucence and good mechanical strength.

Lime glasses have controlled mechanical properties and excellent visual qualities.

Lead glasses have controlled mechanical and electrical properties and high visual quality.

WHERE GLASS?

Because you can get Corning glass in almost any shape or form you wish—because you can be sure of the definite and fine balance of properties required for your specific needs, you can use Corning glass in a wide range of applications. Some of these are:

Ovenware
Coffeemakers
Laboratory ware
Electrical insulation
Gauge glasses
Industrial piping
Range burner plates
Crucibles
Ultraviolet lamps
Thermocouple protecting tubes
Induction furnace linings
Electrical insulation
Lighting ware
Food service dishes
Refrigerator storage dishes
Incandescent lamps and stems
Tumblers
Vacuum bottles
Fluorescent lamps
Tableware
Refrigerator trays
Washer windows
Level vials
Fuses
Lampworked novelties
Bowls for food mixers

FREE BULLETIN

For more complete information on how you can advantageously use glass in your product design, send coupon for Bulletin IZ-1.

It lists specifications of the various types and forms of Corning glasses and tells how our design service can help you.

CORNING MEANS RESEARCH IN GLASS

CORNING GLASS WORKS 50-10 Crystal Street, Corning, N.Y.

Please send me a copy of Bulletin IZ-1, entitled "Designing with Glass for Industrial, Commercial and Consumer Applications."

Name_____ Title_____

Company_____

Street_____

City_____ Zone____ State_____

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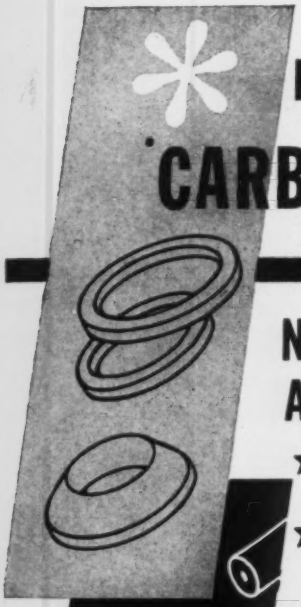
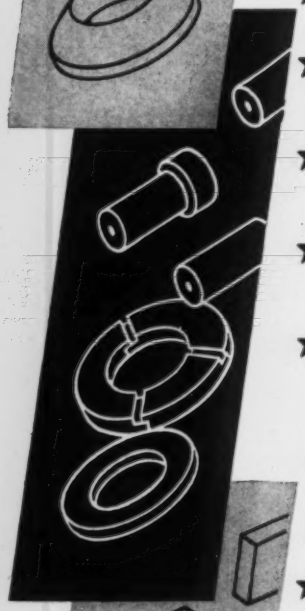
DON'T OVERLOOK CARBON/GRAPHITE!



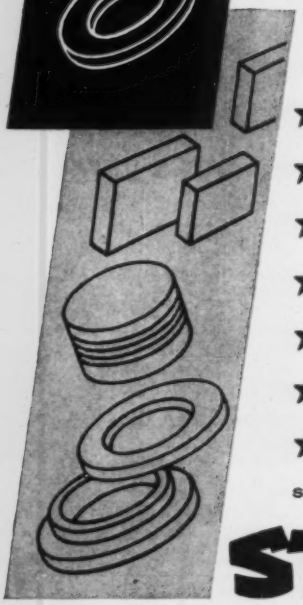
No Other Material Can Do ANY of These:

- ★ Withstand immersion in water from 4,000°F without cracking.
- ★ Resist surface atmospheric action while retaining constant and reproducible contact resistance.
- ★ Be readily processed to provide low friction (graphite) or high friction (carbon) or any desired intermediate value.
- ★ Withstand electric arcing in contacts, lightning arresters and similar applications without appreciable dimensional changes.
- ★ Serve as an electrical conductor which is readily machinable and can operate satisfactorily up to 6,000°F.



No Other Material Can Do ALL of These:

- ★ Resist corrosive action of most gases and chemicals.
- ★ Serve as a semi-permanent, readily-formed mold for casting metals or glass.
- ★ Act as a seal ring around a moving shaft to retain liquids and gases.
- ★ Operate as a sliding contact on commutators and slip rings.
- ★ Serve as a bearing material for vacuum applications or as an insert in ordinary bearings.
- ★ Operate as a friction unit in constant-speed clutches.
- ★ Serve as a non-welding contact, either by itself or in combination with other metals.



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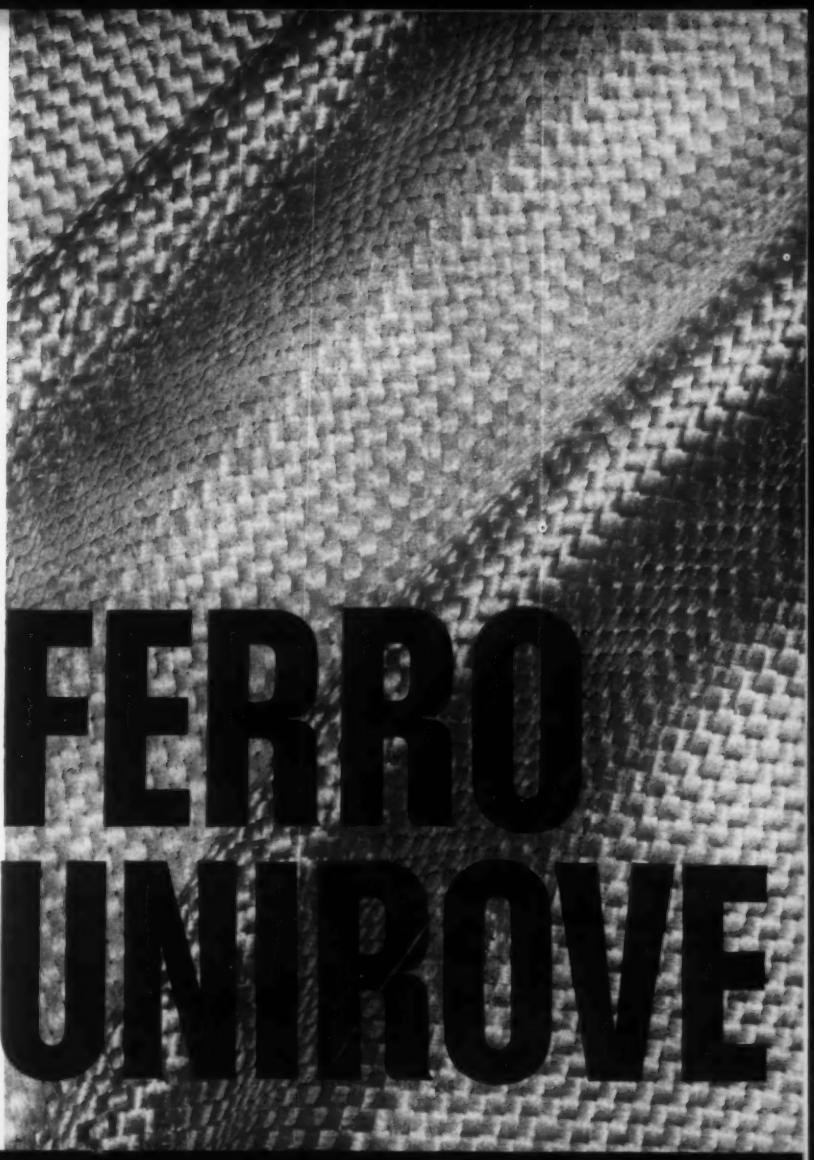

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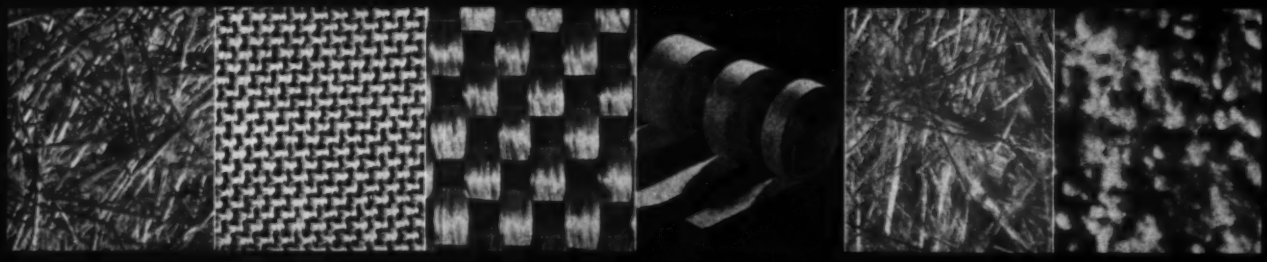

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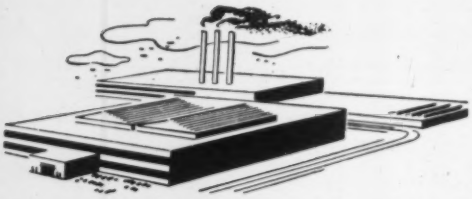

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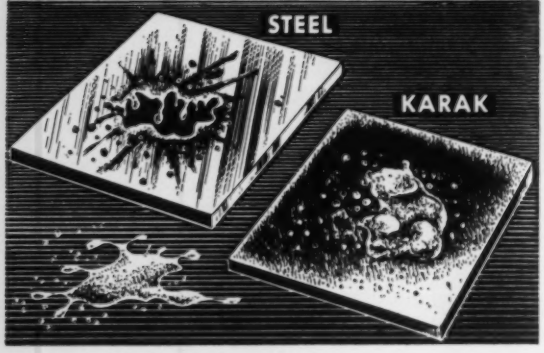

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Includes processes, properties, design and applications . . .

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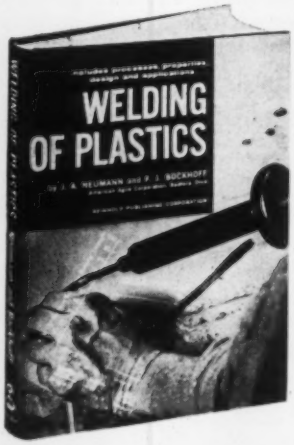
by J. A. NEUMANN and F. J. BOCKHOFF

American Agile Corporation, Bedford, Ohio

Here is the only comprehensive treatment of all phases of this subject ranging from initial design procedures to final detailed fabrication methods. Various physical and chemical properties of individual plastics presently used for welded construction are completely covered with regard to their use in chemical and allied processing. All presently known techniques of welding are covered in detail and many step-by-step procedures with photographs are included. In addition, the book contains one of the most complete corrosion resistance tables yet published, plus a concise guide for the choice of an appropriate plastic construction material. An entire chapter is devoted solely to design considerations as they specifically affect welded construction. Testing and evaluation are also given separate treatment.

The most recent welding materials, such as linear polyethylene, polypropylene, chlorinated polyethers, and the newer fluorocarbons are covered in detail. In addition, the newest welding techniques are presented in a complete, up-to-date manner.



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ceramoplastics and glass-bonded mica

ENGINEERING COMPARA CHART

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ceramoplastics

SUPRAMICA* 620
A compression-molded ceramoplastic made with synthetic mica. Has a maximum temperature endurance of 1550°F (unstressed) and a heat distortion temperature** of 1360°F. Machinable to .0001 inch tolerances.

SUPRAMICA* 500
A compression-molded ceramoplastic made with synthetic mica, that has a maximum temperature endurance of 700°F (unstressed) and a heat distortion temperature** of 900°F. Readily machinable; not precision moldable.

SUPRAMICA* 560
A precision-molded ceramoplastic with a maximum temperature endurance of 932°F (unstressed) and a heat distortion temperature** of 870°F. Inserts may be molded in.

SUPRAMICA* 555
A precision-molded ceramoplastic that withstands a maximum temperature endurance of 650°F (unstressed) and a heat distortion temperature** of 700°F. Moldable with or without inserts.

glass-bonded mica

MYCALEX* 400
A standard grade compression-molded, glass-bonded mica that withstands a maximum temperature endurance of 700°F (unstressed) and a heat distortion temperature** of 850°F. Readily machinable, but not moldable. Inserts must be cemented.

MYCALEX* 410
Glass-bonded mica, precision-molded with or without inserts, for applications involving a maximum temperature endurance of 650°F (unstressed) and a heat distortion temperature** of 690°F.

MYCALEX* 410X
A lightweight, precision-molded glass-bonded mica, with somewhat higher loss factor, having a maximum temperature endurance of 575°F (unstressed) and a heat distortion temperature** of 690°F.

MYCALEX* 385
An arc-resistant glass-bonded mica with excellent resistance to thermal shock, that withstands a maximum temperature endurance of 700°F (unstressed) and a heat distortion temperature** of 850°F. Readily machinable, but not moldable.

*SUPRAMICA, MYCALEX, SYNTHAMICA, "400" and "410X" are registered trademarks of Mycalex Corporation of America; "385", "500", "560", and "620" are trademarks of Mycalex Corporation of America.

**ASTM Test Method D648 (modified for glass-bonded mica) at stress of 264 psi—except as noted.

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The family of the world's most nearly perfect electronic and electrical insulation materials

MYCALEX CORPORATION OF AMERICA—world's largest manufacturer of glass-bonded mica, ceramoplastic and synthetic mica products—offers a wide selection of versatile electrical and electronic insulation materials, whose properties are described in these pages.

Each material offers a unique combination of special engineering advantages and is an *exclusive formulation* of the MYCALEX CORPORATION OF AMERICA. The charts on the following pages point up the many gains that can be achieved with MYCALEX® glass-bonded mica and SUPRAMICA® ceramoplastic materials, including their maximum temperature endurance and heat distortion limits.

Long experience enables our engineers to recommend the particular product which most precisely and most economically fits your requirements.

It is desirable, for this reason, to call upon the services of MYCALEX CORPORATION OF AMERICA while components are in the initial design stages. You will find our technical knowledge and our machining and precision molding skills invaluable in creating accurate, reliable components.

SUPRAMICA ceramoplastics are advanced formulations of SYNTHAMICA® synthetic mica and high-temperature glass. They are available in precision-molded and machinable types, both of which have *total* dimensional stability. This synthetic mica used exclusively in our formulations confers exceptional heat resistance upon our family of SUPRAMICA ceramoplastics . . . permitting maximum temperature endurances up to 1550°F (unstressed).

MYCALEX glass-bonded mica formulations contain high-quality natural mica and electrical grade glasses. They offer high dielectric strength, *total* dimensional stability, high-arc resistance and high-temperature resistance. Depending on formulation, they can be machined or precision-molded to exacting tolerances, and inserts can be molded or cemented in; the thermal expansion of MYCALEX is close to that of stainless steel.

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ENGINEERING COMPARA CHART

A VALUABLE COMPARISON OF

electrical

	DISSIPATION FACTOR 10^6 cycles/sec.	DIELECTRIC CONSTANT 10^6 cycles/sec.	LOSS FACTOR 10^6 cycles/sec.	DIELECTRIC STRENGTH ⅛" thick v/mil	ARC RESISTANCE ASTM Seconds	HEAT DISTORTION TEMPERATURE °F **	MAXIM TEMPERA ENDURA °F
SUPRAMICA 620 ceramoplastic (machinable)	0.0015	7.2	0.011	250	300	1360	1550
SUPRAMICA 500 compression-molded ceramoplastic (machinable)	0.0015	7.0	0.011	500	300	900	700
MYCALEX 400 compression-molded glass-bonded mica (machinable)	0.0018	7.2	0.013	500	300	850	700
SUPRAMICA 555 precision-molded ceramoplastic	0.0015	9.0	0.014	400	250	700	650
SUPRAMICA 560 precision-molded ceramoplastic	0.0020	6.7	0.013	350	250	870	932
MYCALEX 410 precision-molded glass-bonded mica	0.0015	9.2	0.014	400	250	690	650
MYCALEX 410X precision-molded glass-bonded mica	0.0025	6.3	0.016	350	200	690	575
Steatite ceramic	0.0008-0.0035	5.2-6.3	0.0042-0.0220	200-350	500	—	1800
Mica-filled phenolic	0.015-0.040	4.2-5.2	0.021-0.200	250-390	tracks	230-350	250-30
Alkyd polyester molding compound—mineral filled	0.015-0.040	4.6-5.5	0.069-0.220	300-350	75-190	350-425	300-35
*Melamine asbestos filled	0.041-0.050	6.1-6.7	0.250-0.330	320	120-140	265	250-40
*General purpose phenolic-wood flour filled	0.030-0.070	4.0-10.0	0.120-0.490	100-375	tracks	260-340	300-35
*Polytetrafluoroethylene	0.0002	2.0	0.0004	430	200	250 (66 psi)	500
*Polymonochlorotrifluoroethylene	0.0036	2.5	0.009	600	360	160 (66 psi)	390
*Polystyrene	0.0001-0.0004	2.40-2.65	0.0002-0.0011	400-600	60-80	150-195	150-17
Electrical glass	0.0005-0.0100	3.8-14.5	0.0019-0.145	200-400	500	925-1679 ***	700-90
Porcelain	0.0006-0.0200	5.4-7.0	0.003 0.140	40-400	500	—	2200
*Nylon	0.030 0.040	3.4-3.5	0.102 0.140	340-410	130-140	300-360	270-30
*Polyester—glass	0.008-0.030	3.5-6.4	0.028 0.192	275-390	60-180	400	300-35
*Silicone—glass (molding)	0.0020-0.0200	3.2-4.7	0.006-0.094	125-300	20-250	570	450+
*Silicone—glass (laminate)	0.0006-0.0035	3.7-4.3	0.0022-0.0141	150-350	150-250	500	400+
*Cold-molded organic	0.070	6.0	0.420	50-75	75-200	400+	500
*Cold-molded inorganic	—	—	high	50-80	100-600	—	900

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SYNTHAMICA® SYNTHETIC MICA · MYCALEX® THE INSULATOR · SUPRAMICA® CERAMOPLASTIC

MYCALEX
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* [illegible] Plastics Properties Chart, courtesy Modern Plastics Encyclopedia.

** ASTM Test Method D648 (modified for glass-bonded mica) at stress of 264 psi in air or oil.

*** Not in accordance with ASTM Test Method D495.

World's largest manufacturer of glass

F THE PROPERTIES OF INSULATING MATERIALS

hermal			physical							
XIMUM PERATURE URANCE °F	THERMAL EXPANSION 10^{-6}/°C	THERMAL CONDUCTIVITY cal/cm²sec.°C/cm	TENSILE STRENGTH psi	COMPRESSIVE STRENGTH psi	FLEXURAL STRENGTH psi	MODULUS OF ELASTICITY 10^6 psi	IMPACT STRENGTH CHARPY ft. lbs./in. of notch	WATER ABSORPTION 1/8" thick 24 hrs. - %	SPECIFIC GRAVITY	DIMENSIONAL PRECISION AND STABILITY ****
1550	11.6	0.0012	5,000	35,000	10,000	12.5	0.5	nil	3.2	A
700	11.2	0.0012	6,000	40,000	15,000	12.0	1.3	nil	3.0	A
700	10.5	0.0010	6,000	45,000	15,000	11.0	1.0	nil	3.0	A
650	11.4	0.0013	4,000	40,000	12,000	8.5	0.5	nil	3.8	A
932	11.3	0.0015	4,000	25,000	12,000	8.0	0.4	nil	2.7	A
650	10.7	0.0011	5,000	40,000	14,000	7.5	0.7	nil	3.8	A
575	10.0	0.0010	5,000	25,000	12,000	8.0	0.4	nil	2.6	A
800	8.6-10.5	0.0015-0.0020	6,000-10,000	66,000-90,000	16,000-24,000	13.0-15.0	0.3-0.4	0.0-0.05	2.7	C
0-300	19-26	0.0010-0.0014	5,000-7,000	15,000-25,000	8,000-12,000	3.0-5.0	0.30-0.38	0.01-0.10	1.75-1.92	B
0-350	35-50	—	3,000-5,500	18,000-25,000	7,500-10,000	0.5-2.5	0.30-0.35	0.15-0.80	1.60-2.25	B
0-400	20-45	0.0013-0.0017	5,500-7,000	30,000	9,000-11,000	1.6	0.28-0.40	0.08-0.14	1.70-2.00	C
0-350	30-45	0.0004-0.0007	6,500-8,500	22,700-36,000	8,500-12,000	0.8-1.2	0.24-0.60	0.3-1.0	1.32-1.45	C
500	100	0.0006	1,500-3,000	1,700	2,000	0.06	3.0	.005	2.1-2.2	C
390	45-70	0.0006	5,700	32,000-80,000	8,200	.20-.30	3.6	nil	2.1	B
0-170	60-80	0.00024-0.00033	5,000-9,000	11,500-16,000	12,000-16,000	.40-.50	0.25-0.40	0.03-0.05	1.04-1.065	B
0-900	0.8-13	0.001-0.002	5,000-10,000	50,000-175,000	10,000-16,000	7.0-13.0	0.1-0.3	nil	2.2-4.3	B
200	5.0	0.0025	3,000-15,000	25,000-100,000	3,500-15,000	7.0-14.0	0.2-0.3	0.0-2.0	2.3-2.5	C
0-300	100-150	0.0005	7,000-10,900	7,200-13,000	8,000-13,800	0.26-0.40	1.0	0.4-1.5	1.09-1.14	B
0-350	15-33	0.0010-0.0016	10,000-50,000	15,000-50,000	10,000-80,000	0.8-4.5	1.5-30	0.01-0.50	1.35-2.3	B
0+	8	0.0004	4,000-5,000	9,000-15,000	9,000-14,000	—	3.0-15.0	0.10-0.20	1.68-2.00	B
0+	5-10	0.0007	10,000-30,000	35,000-46,000	10,000-38,000	1.5-2.0	8.0-15.0	0.15-0.65	1.6-1.9	B
00	—	—	1,400-3,000	6,000-15,000	3,700-10,000	—	0.40	0.55-2.0	1.9-2.2	B
00	—	—	1,500-2,200	12,000-18,000	2,000-7,500	—	0.15-0.40	0.5-15.0	1.6-2.2	B

ss-bonded mica, ceramoplastic and synthetic mica products

ENGINEERING COMPARA CHART

thermal expansion

Fahrenheit Temperature Limits For Various Materials

SYNTHAMICA 202 synthetic mica melts	2550
Electrical porcelain—firing temperature	2400
Glaze for porcelain—firing temperature	2250
Raw lead pottery glazes—firing temperature	2000-2060
Copper melts	1981
Furnace temperatures in glass manufacture	1900-2800
SYNTHAMICA 202 synthetic mica—maximum heat resistance*	1832
Silver melts	1762
Natural phlogopite mica—maximum heat resistance	1562
SUPRAMICA 620 ceramoplastic—maximum heat resistance*	1550
SUPRAMICA 620 ceramoplastic—heat distortion (264 psi)	1360
Aluminum melts	1220
Silver solders melt	1165-1450
SUPRAMICA 560 ceramoplastic—maximum heat resistance*	932
SUPRAMICA 500 ceramoplastic—heat distortion (264 psi)	900
Cold-molded refractory and phospho-asbestos—maximum heat resistance	900-1300
Calcium aluminum silicate—maximum heat resistance	900
SUPRAMICA 560 ceramoplastic—heat distortion (264 psi)	870
MYCALEX 400 glass-bonded mica—heat distortion (264 psi)	850
MYCALEX 385 glass-bonded mica—heat distortion (264 psi)	850
Aluminum alloy melting points	850-1225
Muscovite mica—maximum heat resistance	800-1000
Zinc melts	785
SUPRAMICA 555 ceramoplastic—heat distortion (264 psi)	700
SUPRAMICA 500 ceramoplastic—maximum heat resistance*	700
MYCALEX 400 glass-bonded mica—maximum heat resistance*	700
MYCALEX 385 glass-bonded mica—maximum heat resistance*	700
MYCALEX 410 glass-bonded mica—heat distortion (264 psi)	690
MYCALEX 410X glass-bonded mica—heat distortion (264 psi)	690
MYCALEX 410 glass-bonded mica—maximum heat resistance*	650
SUPRAMICA 555 ceramoplastic—maximum heat resistance*	650
Magnesium alloy melting points	650-1200
Lead melts	621
Cadmium melts	610
MYCALEX 410X glass-bonded mica—maximum heat resistance*	575
Silicone-glass heat distortion	575
Cold-molded plastic (organic)—sustained service	500
Polytetrafluoroethylene—sustained service*	500
Silicone-glass sustained service	480
Tin melts	450
Silicone rubber—sustained service	425
Polyester-glass heat distortion	400
Cold-molded plastic (organic) heat distortion	400
Cellulose-filled melamine heat distortion	400
Polymonochlorotrifluoroethylene—sustained service*	390
Polyester, mineral-filled, putty—heat distortion	374-425
Mercury boils	357
"Hottest spot"—Class H insulation	356
Diallyl Phthalate glass-filled	350-400
Alkyd: polyester, mineral-filled, granular—heat distortion	350-400
Epoxy-glass cloth—maximum temperature	315
Silicone elastomer—sustained service	300-500
Nylon (polyamide) heat distortion (66 psi)	300-360
Casein heat distortion	300
Urea-formaldehyde heat distortion	275
Polytetrafluorosthylene heat distortion (66 psi)	270
"Hottest spot"—Class B insulation	266
Melamine-formaldehyde (filled) heat distortion	266-400
Diallyl Phthalate (alpha cellulose filler) heat distortion	265-310
Phenol-formaldehyde (mica) heat distortion	260-350
Phenol-formaldehyde (wood flour) heat distortion	260-340
Hard rubber (mineral-filled) heat distortion	260
Sulphur (rhombic) melts	235
"Hottest spot"—Class A insulation	221
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Epoxy—maximum recommended use	212
Water boils	212
Polyvinyl carbazole heat distortion	210-300
Vulcanized fiber—upper limit	200
"Hottest spot"—Class O insulation	194
Polydichlorostyrene heat distortion	185-230
Polymonochlorotrifluoroethylene heat distortion (66 psi)	160
Polystyrene heat distortion	152-210
Methyl methacrylate heat distortion	150-210
Styrene copolymer heat distortion	148-235
Vinyl chloride heat distortion	140-185
Cellulose nitrate heat distortion	140-160
Hard rubber (no filler) heat distortion	140
Vinylidene chloride heat distortion	130-150
Cellulose acetate butyrate heat distortion	120-210
Cellulose acetate heat distortion	115-235
Ethyl cellulose heat distortion	115-190
Vinyl butyral heat distortion	115-140
Polyethylene heat distortion (66 psi)	107
Normal room temperature	72
Water freezes	32
Mercury freezes	−38
Silicone elastomer loses flexibility	−60
Dry ice (CO_2) sublimes	−109
MYCALEX glass-bonded mica undamaged	−110
SUPRAMICA ceramoplastic undamaged	−110

*unstressed

SYNTHAMICA® SYNTHETIC MICA · MYCALEX® SINCE 1919 THE INSULATOR · SUPRAMICA® CERAMOPLASTIC

MYCALEX
CORPORATION OF AMERICA

One of the important and most useful characteristics of SUPRAMICA ceramoplastics and MYCALEX glass-bonded mica is the coefficient of thermal expansion, which is very close to that of Type 446 stainless steel. This property gives assurance of permanent anchorage of inserts molded into SUPRAMICA 555 or 560, or MYCALEX 410, eliminating possibilities of differential expansion gaps that introduce corona noise, corona heating and possible loss of the insulator. No bonding agent is necessary when molding inserts into SUPRAMICA 555 or 560 or MYCALEX 410. Inserts must be cemented when used with the machinable materials SUPRAMICA 620 or 500 or MYCALEX 400.

The absolute dimensional stability of both SUPRAMICA and MYCALEX, plus their thermal expansion properties, make these materials ideal for precision applications where even the slightest variation in dimensions would upset delicately balanced equipment. Bonding to and around metallic parts in avionic constructions for effective control of moisture transmission and uniform stress distribution; the manufacture of precision commutator plates; and molding to .0005" tolerances in other electronic components are some of the applications for which these materials have proved to be unsurpassed.

THERMAL EXPANSION COEFFICIENTS OF INSERT METALS AND INSULATING MATERIALS

10-6/deg. C.

	0.8-13.0	ELECTRICAL GLASS
INVAR	1.1	
	5.0-7.0	PORCELAIN
TITANIUM	5.9	
	5.0-10.0	SILICONE/GLASS LAMINATES
	8.6-10.5	STEATITE
PLATINUM	8.8	
ILLIUM R	9.2	
410 STEEL	9.9	
	10.0	**MYCALEX® 385** GLASS-BONDED MICA
	10.0-30.0	POLYESTER/GLASS
420 STEEL	10.3	
446 STEEL	10.5	**MYCALEX® 400** GLASS-BONDED MICA
	10.7	**MYCALEX® 410** GLASS-BONDED MICA
430 STEEL	10.8	
414 STEEL	11.0	
	11.3	**SUPRAMICA® 560** CERAMOPLASTIC
330 STEEL	11.3	**SUPRAMICA® 500** CERAMOPLASTIC
	11.4	**SUPRAMICA® 555** CERAMOPLASTIC
INCONEL	11.5	
	11.6	**SUPRAMICA® 620** CERAMOPLASTIC
PALLADIUM	11.7	
431 STEEL	11.7	
1010 STEEL	12.1	
WROUGHT IRON	12.1	
1020 STEEL	12.1	
NICKEL	13.0	
ILLIUM G	13.5	
MONEL	14.0	
DURIMET	14.1	
310 STEEL	14.4	
309 STEEL	14.9	
316 STEEL	16.0	
NICKEL SILVER	16.2	
BERYLLIUM COPPER	16.5	
321 STEEL	16.7	
5% PHOSPHOR BRONZE	16.8	
301 STEEL	16.9	
304 STEEL	17.3	
RED BRASS	17.6	
COPPER	17.7	
YELLOW BRASS	18.9	
SILVER	19.1	
ALUMINUM ALLOYS	19.8-24.3	
	20.0-45.0	MELAMINE ASBESTOS FILLED
NAVAL BRASS	20.1	
TIN	21.1	
	22.0-27.0	MICA-FILLED PHENOLIC
DOWMETAL C	25.2	
	30.0-45.0	GENERAL PURPOSE PHENOLIC
	35.0	ALKYD-MINERAL FILLED
	45.0-70.0	POLYMONOCHLOROTRIFLUOROETHYLENE
	60.0-80.0	POLYSTYRENE
	99.0	POLYTETRAFLUOROETHYLENE
	100.0-150.0	NYLON

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Finishes and Coatings

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Chromate Conversion Coatings. Allied Research Products, Inc., 28 pp, illus. Discusses chromate conversion coatings for zinc, cadmium, copper, brass, bronze, aluminum, magnesium and silver. Also covers clear protective coatings for all metals. **150**

Coatings for Metal. Amchem Products, Inc., 8 pp, No. 1413D. Method of application, purpose of coating and typical applications of a line of chemical conversion coatings for aluminum, copper and copper alloys, iron and steel, zirconium, and other metals. **151**

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Flocked Paper. Cellusuede Products, Inc., illus. Sample kit containing actual swatches of colored flocked paper. Suggestions for cutting, folding and printing the flocked paper. **154**

Colored Conversion Coatings. Chemical Corp., 4 pp. Tells how to produce colored chromate conversion coatings on zinc-plated parts. **155**

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Metal Cleaning. Oakite Products, Inc. Series of technical bulletins give information on metal cleaning and preparation of metals for painting. Covered are: chemistry and techniques of metal cleaning, conversion coatings, rust prevention, paint stripping, ultrasonic cleaning, barrel finishing and many others. **170**

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Fusion Bond Finishes. Polymer Corp., Whirlclad Div., 4 pp, illus. Characteristics, properties and uses of cellulosic, nylon, polyethylene and chlorinated polyether finishes for metal parts. **172**

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Selective Plating. Sifco Metachemical Inc., 4 pp, illus. Process of electroplating selected areas without using immersion tanks. For quick precision plating of electronic parts and build-up of parts to exact size without disassembly. **175**

Dip Coating Process. Steere Enterprises, Inc., 4 pp, illus. Advantages, uses and characteristics of a low cost dipping process which produces plastics products, plastic-coated metal parts and protective covers for precision machined parts. **176**

Plastisols, Organisols. Reynolds Chemical Products Co., Div. of Stubnitz-Green Corp., 8 pp, illus. Information on plastisols and organisols used as coatings for paper, steel, bottles, gloves, rope, wire and plating racks. **177**

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Plasma Arc Coating. Linde Co., Div. of Union Carbide Corp., 8 pp, illus. Describes a plasma arc plating process for applying coatings and fabricating shapes. Tells what materials can be applied and where they can be used. **179**

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Finishes and Coatings

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Electrodeposited Coatings

Type →	Aluminum	Antimony	Arsenic	Bismuth	Cadmium	Chromium
BASE METALS	Magnesium, steel, copper, zinc, nickel, silver, gold	(experimental)	Brass	(experimental)	Steel, copper and its alloys, cast and malleable iron	Ferrous and nonferrous metals
PHYSICAL PROPERTIES						
Ther Cond, Btu/hr/sq ft/°F/ft	122	10.2	—	4.6	5.3	—
Elec Res, microhm-cm	2.8	41.7	35	119	7.5	14–66
Color (natural)	White	White (bright)	Gray or black	White or gray	White (bright)	White (bright) or black
Reflectance When Polished (5000 A), %	—	50	—	—	—	—
Melting Point, F	1220	1166	1139	520	610	2939
Min Thickness, mil	0.1	—	—	—	0.15	0.01
MECHANICAL PROPERTIES						
Brinell Hardness	—	—	—	—	35–50	700–1000
Abrasion Resistance[a]	Poor	—	—	—	Fair	Excellent
CORROSION RESISTANCE, 10^{-6} ipy						
Atmosphere	—	—	—	—	250–510	—
Sea Water	20–3400	—	—	—[c]	700	—
SOLDERABILITY						
As Plated	—	—	—	—	Good	Poor
After 192-Hr Salt Spray	—	—	—	—	Poor	Poor
COST	Moderate	—	—	—	Moderate	Moderate
USES[b]	c, e	c, d	D	c	C, d, w	c, D, e, R, W

Type →	Cobalt	Copper	Gold	Indium	Iron	Lead
BASE METALS	Iron, steel, copper and its alloys	Most ferrous and nonferrous metals	Copper, brass, nickel, silver	Silver-plated steel	Ferrous metals	Most ferrous and nonferrous metals
PHYSICAL PROPERTIES						
Ther Cond, Btu/hr/sq ft/°F/ft	—	222	169	—	38.7	20.1
Elec Res, microhm-cm	6.2	3–8	2.4	8.4	10	22.6
Color (natural)	Gray	Pink or red (bright)	Yellow (bright)	White	Gray	Gray
Reflectance When Polished (5000 A), %	—	44	47	—	0.55	—
Melting Point, F	2723	1981	1944	311	2795	621
Min Thickness, mil	—	0.1	0.002	0.1	—	0.25
MECHANICAL PROPERTIES						
Brinell Hardness	—	60–150	5	—	150–300	5
Abrasion Resistance[a]	—	Fair	Poor	Poor	Good	Poor
CORROSION RESISTANCE, 10^{-6} ipy						
Atmosphere	—	54–464	—	—	—	9–27
Sea Water	—	2000	—	—	—	400–600
SOLDERABILITY						
As Plated	—	Good	Good	Good	Fair	—
After 192-Hr Salt Spray	—	—	Good	—[c]	Poor	—
COST	—	Low	High	—	Low	Low
USES[b]	c, e, r	c, d, E	c, D, e	c, d, W	e, R, w	C, e, w

Notes: See opposite page.

Electrodeposited Coatings

Type →	Magnesium	Manganese	Molybdenum	Nickel	Palladium	Platinum
BASE METALS	(experimental)	Iron, aluminum, copper and its alloys	Zinc, cadmium	Most ferrous and nonferrous metals	Copper and its alloys	Lead, tin, zinc, white gold
PHYSICAL PROPERTIES						
Ther Cond, Btu/hr/sq ft/°F/ft	91	—	83.8	34.4	40.6	40.2
Elec Res, microhm-cm	4.6	5	5.7	7.4–10.8	11	10
Color (natural)	White	Gray	Gray	Gray, white (bright)	Bright	Gray (bright)
Reflectance When Polished (5000 A), %	0.72	—	46	61	—	58
Melting Point, F	1204	2300	4748	2651	2820	3223
Min Thickness, mil	—	—	—	0.1	0.02	Flash
MECHANICAL PROPERTIES						
Brinell Hardness	—	—	—	150–500	—	—
Abrasion Resistance[a]	—	—	Excellent	Excellent	—	—
CORROSION RESISTANCE, 10^{-4} ipy						
Atmosphere	—	—	—	1–160	—	—
Sea Water	10,000–80,000	—	—	300–1000	—	—
SOLDERABILITY						
As Plated	—	—	—	Good	—	—
After 192-Hr Salt Spray	—	—	—	Poor	—	—
COST	—	—	—	Moderate	High	High
USES[b]	Experimental	Experimental	Experimental	C, D, E, R, W	c, D	c, D

Type →	Rhenium	Rhodium	Selenium	Silver	Tin	Titanium
BASE METALS	(experimental)	Most ferrous and nonferrous metals	(experimental)	Most ferrous and nonferrous metals	Most ferrous and nonferrous metals	Steel, nickel, copper
PHYSICAL PROPERTIES						
Ther Cond, Btu/hr/sq ft/°F/ft	—	50.9	—	244	36.3	—
Elec Res, microhm-cm	21	4.7	12	1.6	11.5	3.2
Color (natural)	Gray (bright)	White (bright)	Gray	White (bright)	White	—
Reflectance When Polished (5000 A), %	—	76	—	91	—	—
Melting Point, F	5732	3553	423	1760	448	3272
Min Thickness, mil	—	0.001	—	0.1	0.015	—
MECHANICAL PROPERTIES						
Brinell Hardness	250	400–800	—	50–150	5	—
Abrasion Resistance[a]	Good	Excellent	—	Poor	Poor	—
CORROSION RESISTANCE, 10^{-4} ipy						
Atmosphere	—	—	—	—	72–320	—
Sea Water	—	—	—	40	30–90	—
SOLDERABILITY						
As Plated	—	—	—	—	Good	—
After 192-Hr Salt Spray	—	—	—	—	Poor	—
COST	—	Moderate	—	High	Moderate	—
USES[b]	d	c, D	Rectifiers	C, D, e, w	Experimental	Experimental

[a] Even though some electroplates abrade easily they may still have excellent appearance (e.g., gold and silver), or may even provide an excellent bearing surface (e.g., indium, silver and lead).

[b] Capital letter indicates frequent use, small letter infrequent. C = corrosion protection; D = decoration; E = electroforming; R = reclaiming; W = wear resistance.

continued on next page

Electrodeposited Coatings

Type →	Tungsten	Zinc	Zirconium	Cobalt-Nickel	Copper-Tin (bronze)	Copper-Zinc (brass)
BASE METALS	(experimental)	Ferrous metals	(experimental)	(experimental)	Steel, copper, brass, zinc	Iron, steel, aluminum, zinc
PHYSICAL PROPERTIES						
Ther Cond, Btu/hr/sq ft/°F/ft	84.7	64.2	—	—	—	—
Elec Res, microhm-cm	5.5	5.8	41	—	—	—
Color (natural)	Gray	White (bright)	—	Gray	Pink (bright)	Yellow (bright)
Reflectance When Polished (5000 A), %	0.49	55	—	—	—	—
Melting Point, F	6098	786	3452	—	—	—
Min Thickness, mil	—	0.15	—	—	0.5	0.1
MECHANICAL PROPERTIES						
Brinell Hardness	—	40–50	—	—	—	—
Abrasion Resistance[a]	—	Fair	—	Good	Good	Fair
CORROSION RESISTANCE, 10^{-4} ipy						
Atmosphere	—	8–210	—	—	—	—
Sea Water	—	1000–6000	—	—	—	—
SOLDERABILITY						
As Plated	Good	—	—	—	—	—
After 192-Hr Salt Spray	Poor	—	—	—	—	—
COST	—	Low	—	—	Moderate	Moderate
USES[b]	Experimental	C, d	Experimental	Magnetic	c, D, w	c, D

Type →	Lead-Tin	Nickel-Tin	Phosphorus-Nickel-Cobalt	Tin-Zinc	Tungsten-Nickel-Cobalt-Iron
BASE METALS	Steel, copper, brass	Most ferrous and nonferrous metals	—	Most ferrous and nonferrous metals	—
PHYSICAL PROPERTIES					
Ther Cond, Btu/hr/sq ft/°F/ft	—	—	—	—	—
Elec Res, microhm-cm	—	—	110–118	—	—
Color (natural)	White	White (bright)	Bluish (bright)	White	Gray
Reflectance When Polished (5000 A), %	—	15–118	—	—	—
Melting Point, F	—	—	—	—	—
Min Thickness, mil	0.2	0.5	—	0.15	—
MECHANICAL PROPERTIES					
Brinell Hardness	—	625 (Vickers)	—	—	—
Abrasion Resistance[a]	Poor	Good	—	Good	—
CORROSION RESISTANCE, 10^{-4} ipy					
Atmosphere	—	—	—	—	—
Sea Water	—	—	—	—	—
SOLDERABILITY					
As Plated	Good	—	—	Good	—
After 192-Hr Salt Spray	—	—	—	Poor	—
COST	Moderate	Moderate	—	Moderate	—
USES[b]	c, w	C, D	C, d, e, w	C	C, e, r, w

[a] Even though some electroplates abrade easily they may still have excellent appearance (e.g., gold and silver), or may even provide an excellent bearing surface (e.g., indium, silver and lead).

[b] Capital letter indicates frequent use, smaller letter infrequent. C = corrosion protection; D = decoration; E = electroforming; R = reclaiming; W = wear resistance.

Sprayed Metal Coatings

Type →	Aluminum	Babbitt A[a]	Brass (65:35)	Bronze AA[b]	Commercial Bronze	Manganese Bronze	Phosphor Bronze
Specific Gravity	2.41	6.67	7.45	7.06	7.57	7.26	7.68
Ult Ten Str, 1000 psi	19.5	—	12	29	11.5	12	18
Strain at Ult Str, %	0.23	—	0.45	0.46	0.42	0.46	0.35
Rockwell Hardness	H72	H58	B22	B78	B18	B27	B20
Shrinkage, in./in.	0.0068	—	0.009	0.0055	0.011	0.009	0.010
Spraying Speed, lb/hr	18	95	32	24	24	36	31
Spraying Efficiency, %[c]	89	69	81	77	82	79	85
Major Characteristics and Uses[d]	Good corrosion and heat resistance	Good bearing properties	Sprays fast. Fair machine finish	Hard, very wear resistant. Easily machined	Softest bronze. Fair machine finish	Excellent machine finish. Special uses only	Fair machine finish. Special uses only

[a]Lead-free, high tin alloy. [b]Aluminum-iron-bronze. [c]Percent of metal deposited.
[d]All metals have about the same shiny surface after spraying, but surfaces of the various metals differ after machining.

Type →	Tobin Bronze	Copper	Lead	Molybdenum	Monel	Nickel	18-8 Stainless
Specific Gravity	7.46	7.54	10.21	8.86	7.67	7.55	6.93
Ult Ten Str, psi	13	—	—	7.5	21	17.5	30
Strain at Ult Str, %	0.51	—	—	0.30	0.26	0.30	0.27
Rockwell Hardness	B27	B32	—	C38	B39	B49	B78
Shrinkage, in./in.	0.0104	—	—	0.003	0.009	0.008	0.012
Spraying Speed, lb/hr	36	29	80	8	17	18	21
Spraying Efficiency, %[c]	80	80	65	87	85	79	81
Major Characteristics and Uses[d]	General purpose. Fair machine finish	Electrical uses; brazing	Good corrosion resistance. X-ray shielding	Used as bonding coat. Excellent bearing properties	Good corrosion resistance. Good machine finish	Good corrosion resistance. Fair machine finish	High corrosion resistance. Good wearing properties

Type →	High Cr Stainless	Steel (LS)[e]	Steel (0.10% C)	Steel (0.25% C)	Steel (0.80% C)	Tin	Zinc
Specific Gravity	6.74	6.78	6.67	6.78	6.36	6.43	6.36
Ult Ten Str, psi	40	33.5	30	34.7	27.5	—	13
Strain at Ult Str, %	0.50	0.54	0.30	0.46	0.42	—	1.43
Rockwell Hardness	C29	C25	B89	B90	C36	—	H46
Shrinkage, in./in.	0.0018	0.002	0.008	0.006	0.0014	—	0.010
Spraying Speed, lb/hr	19	18	19	19	19	95	61
Spraying Efficiency, %[c]	81	87	87	87	87	73	66
Major Characteristics and Uses[d]	High hardness and wear resistance. Grind finish	Good mechanical and finishing properties	Simple bearing surfaces and press fits. Excellent machine finish	Harder and lower shrinkage than 0.10C. Excellent machine finish	Very hard and wear resistant. Good bearing properties. Grind finish	Good corrosion resistance, especially with foods	Good all-around corrosion resistance

[e]Low shrinkage.

Hot Dip Coatings[a]

Type →	**Aluminum** (aluminized)	**Zinc** (galvanized)	**Lead**	**Tin**	**Lead-Tin** (terne)
Base Metals	Steel	Steel	Steel and copper	Steel or copper	Steel
Thickness	Most commonly applied in thicknesses of 1 to 2 mils	For structural steel shapes, plates and bars, weight of coating should be 2 oz per sq ft	8–40 lb per double base box	Sheet: 1.25–4.0 lb per double base box. Wire, strip: 0.005 mil. Fabricated parts: 0.3–0.5 mil	8–40 lb per double base box
Important Properties	Combines corrosion res and heat reflectivity of aluminum with mechanical and physical properties of steel; withstands up to 900 F without discoloring and up to 1250 F without descaling; in some cases can be used up to 1650 F	Combines high corrosion res with low cost; has slower corrosion rate than iron; corrosion products are white and nonstaining; provides electrolytic protection to iron	Major advantage is high res to atmospheric corrosion and chemicals, especially sulfuric and hydrochloric acids, and brine; superficial protective oxide film regenerates itself when damaged; can withstand severe deformation	Very good res to tarnishing and staining indoors, pure rural atmospheres, and food; sheet can be severely deformed without damage (lends itself to stamping, drawing, rolling, lock-seaming and bending); sheet is readily soldered	Provides some of the advantages of tin coatings at lower cost; ductility and good adhesion allow deep drawing; excellent paint-holding properties
Limitations	Above 900 F, coating begins to alloy with base metal to form refractory layer which will not return to original state	Life of coatings is about five to ten times greater in rural than in industrial atmospheres containing sulfur and acid gases	Poor res to wear and abrasion; poor adhesion; pinholes may form during application; performs better in industrial than rural atmospheres	Presence of many minute pores causes accelerated corrosion, especially in wet environments; res to marine and industrial atmospheres not very good	Provides only mechanical protection against corrosion
Remarks	Corrosion res is often superior to that of galvanized steel, but aluminum coating is more expensive	Greater protection can be obtained by increasing thickness	Adhesion can be improved by adding small quantities of alloying ingredients; pinholes can be eliminated by slight working or burnishing	Corrosion res markedly improved by increasing thickness and controlling porosity	Corrosion res can be improved greatly by using organic coatings
Uses	High temp applications such as fire walls, water heater and oven liners, mufflers, heat exchanger tubes, space heater parts, combustion chambers	Roofing and siding, nails, wire, tanks, boilers, pails, and wide range of hardware for indoor and outdoor use	Wire, pole-line hardware, bolts, washers, tanks, barrels, cans, air ducts. Good adhesion of organic coatings has proved valuable for such outdoor uses as gutters, flashing and corrugated siding	Hot dipped tin coatings on food cans have largely been superseded by tin electroplates; however, the heavier coatings produced by hot dipping are useful for some fabricated parts and castings	If used in sufficient thickness, coatings provide good protection for such things as gasoline tanks and roofing, and benches and cabinets used in chemical laboratories

[a] For all types except terne, two layers are formed on the base metal: the outer layer is generally relatively pure coating metal, the intermediate layer is an alloy of the coating metal and the base metal. Terne coatings generally contain 10–25% tin and 75–90% lead.

Immersion Coatings

Type →	Electroless Nickel	Tin	Copper	Gold	Silver
Base Metals	Most ferrous and nonferrous metals	Copper, brass, bronze, aluminum, steel	Steel, brass, aluminum and printed circuit boards	Most ferrous and nonferrous metals	Most metals except lead, zinc, aluminum and other very active metals; copper, nickel and steel best
Thickness	From 1 to 5 mils, depending on end use	Decorative: 0.015 mil; heavy duty: up to 2 mils	From 0.1 to 1 mil	Usually about 0.001 mil	Usually about 0.001 mil, but sometimes as high as 0.03 mil
Important Properties	Because of their amorphous structure and phosphorus content (8–10%), these coatings have better abrasion resistance than electrolytic or wrought nickel; hardness is relatively high (about R_c 50, which can be heat treated to R_c 64)	Combines bright appearance, good frictional properties and ease of application with low cost	High electrical conductivity, good lubrication properties	Good electrical conductivity and emissivity; bright, attractive appearance	Bright, attractive appearance
Limitations	Generally more expensive than electroplated nickel	Corrosion resistance is only fair; plating usually stops when base metal is covered	Not especially noted for decorative appeal	Poor resistance to discoloration and abrasion	Poor resistance to tarnishing and abrasion
Remarks	Although coating is used primarily for functional properties, a smooth, bright deposit can be obtained with buffed metals	Heavier coatings can be produced by placing base metal in contact with a dissimilar metal, thereby generating an electric current and promoting additional plating	Unusual appearance can be used to advantage for such things as inexpensive hardware and casket parts	Relatively inexpensive due to extreme thinness; discoloration and abrasion resistance can be improved with a clear lacquer finish	Relatively inexpensive due to extreme thinness; can be protected somewhat against tarnishing with a clear lacquer finish
Uses	Protecting parts from corrosion and preventing product contamination. Tank car interiors, oil refinery air compressors, missile fuel injector plates, pumps, reciprocating surfaces; aluminum electronic devices (to facilitate soldering); stainless steel (to facilitate brazing)	Decorative finishing of small parts such as safety pins, thimbles and buckles; also used on copper tubing to prevent discoloration from water and on aluminum engine pins to provide lubrication during break-in periods	Because of their conductivity, these coatings have proved particularly useful for printed circuits. Because of their good lubrication properties, they are also used on steel wire in die forming operations	Principally used on costume jewelry, trophies, auto trim and many inexpensive novelties. Their conductivity and solderability have proved useful in electrical applications such as printed circuits, transistors and connectors. Emissivity properties valuable in some missile applications	Cheap decorative products, minor electronic parts and maintenance plating

Diffusion Coatings*

Type →	Calorized	Carburized	Chromized	Cyanided, Carbonitrided
Base Metals	Carbon, low alloy steels	Carbon and alloy steels low enough in carbon content (<0.45%) to take up that element readily	Low and high carbon steels, many alloy steels, stainless steels, tool steels, cast iron, iron powder parts	Same steels as used for carburizing
How Applied	Aluminum introduced into surface by treating metal in powdered aluminum compound or aluminum chloride vapor, or by spraying and subsequently heat treating; alloy coating (5–40 mils) contains about 25% aluminum	Carbon introduced into surface by heating solid, liquid or gaseous carbon in contact with base metal at temperatures above the transformation range, generally 1450–1750 F	Chromium introduced into surface by heating metal in contact with a chromium-containing powdered compound at 1500–1900 F. High chromium-iron alloy is formed on low-carbon ferrous metals (3 mils); chromium carbide case is formed on high carbon metals (½–2 mils)	Carbon and nitrogen introduced into surface by heating metal in a liquid cyanide bath (cyaniding) or in a carbonaceous and nitrogeneous (carbonitriding) bath, the temperature ranging from 1200–1600 F
Important Properties	Resistance to high temperature oxidation (long time service at temperatures up to 1400 F); protects by sealing metal from surrounding air	High strength and toughness in core can be combined with extreme surface hardness; plain carbon steels are used if core properties are not too critical; alloy steels are used if strength and toughness are needed in core	High resistance to wear, abrasion and corrosion; high hardness (1600–1800 VPN)	Hard and wear resistant surface; warping is less serious than in carburizing; quenching is usually necessary for full hardness
Uses	Chemical and metal process pots, bolts, air heater tubes, and parts for furnaces and steam superheaters	Gears, cams, pawls, racks and shafts	Aircraft, railroad and automotive parts, combustion equipment, mechanical equipment, tools, heating apparatus	In general, same as carburized

Type →	Nickel-Phosphorus	Nitrided	Sherardized	Siliconized
Base Metals	Ferrous metals	Primarily special nitriding steels. Also medium carbon steels containing chromium and molybdenum, stainless steels, some cast irons	Ferrous and nonferrous metals	Low carbon (<0.25%), low sulfur (<0.04%) steels
How Applied	Nickel-phosphorus introduced into surface by painting metal with mixture of nickel oxide, dibasic ammonium phosphate and water, and then heating	Nitrogen introduced into surface by heating metal in contact with ammonia or other nitrogeneous material, the temperature ranging from 930–1050 F	Zinc introduced into surface by heating base metal in a zinc powder for 3–12 hr at 650–750 F	Silicon introduced into surface by heating metal in contact with silicon carbide and chlorine at 1700–1850 F
Important Properties	Corrosion resistance approaches that of stainless steel and high nickel alloys; must be heat treated in controlled atmosphere; little porosity; poor resistance to heat and abrasion	High wear resistance, retention of hardness at elevated temperatures; good resistance to certain types of corrosion; produces minimum distortion	Improves corrosion resistance; coatings are not as protective as plated or hot dipped zinc coatings, but are more uniform	High resistance to wear, heat and corrosion; improves hardness; surfaces are nongalling; case (5–10 mils) is brittle
Uses	Pipe and fittings	In general, same as carburized	Small steel parts such as nuts, bolts, and washers, or castings that must resist atmospheric corrosion	Pump shafts; cylinder liners; valves, valve guides and fittings; conveyor chain links

* Surface alloying treatments for metals.

Vapor Deposited Coatings

Type ➡	Vacuum Metallized	Cathode Sputtered	Vapor Plated
Coating Metals	Primarily aluminum; also cadmium and selenium	Primarily gold and silver; also platinum and palladium; in general, any low-vapor-pressure metal	Primarily nickel; also iron, chromium, cobalt, molybdenum and some precious metals
Base Materials	Primarily zinc, steel, plastics; also aluminum, glass, paper	Most metals and nonmetallics	Most metals and nonmetallics
How Applied	Evaporation—Metal is brought in contact with hot filament (tungsten, molybdenum or platinum) in a vacuum of at least 10^{-4} mm of Hg; the metal evaporates (in 5–15 sec) and condenses on all cool surfaces that lie in straight path from filament	Ion bombardment—A high voltage (10,000 v or more) is applied across two electrodes; ion bombardment vaporizes the cathodic metal and deposits it as a crystalline, fine-grained coating on material placed near anode	Thermal decomposition ("gas plating")—Metal to be deposited must exist in the form of a gaseous compound that decomposes at a temperature higher than its vaporization temperature; part to be plated is heated above this decomposition temperature of the compound and inserted in the plating chamber
Important Properties	Deposition rates are slow; process is expensive compared to electroplating unless restricted to large runs of small or medium-sized parts and to thin coatings. For thin films (0.003 to 0.005 mil), vacuum metallizing is best method—it is low cost and produces finely controlled and uniform deposits which closely follow contours of base surface. Abrasion resistance is generally low. Corrosion resistance very good for cadmium coated parts	Lower vacuum is required than in vacuum metallizing (only 0.01–0.1 mm Hg) and hence less expensive equipment, but deposition rates are slower, and some metals, including aluminum, cannot be deposited. Thin films are generally highly porous, but deposits of 0.04 mil are satisfactory. Temperature rise produced in substrate is often higher than in vacuum metallizing. It is difficult to avoid oxide contamination	Method is adaptable to odd-shaped objects, deposits coatings with greater speed than any conventional plating process, makes possible the deposition of alloys, and is applicable to porous surfaces such as powder metal parts. Gaseous compounds are expensive and, in some cases, toxic
Uses	Aluminum-coated zinc or steel—hardware, costume jewelry, optical reflectors, instrument parts, automotive trim and interior hardware; selenium-coated nickel-plated aluminum—selenium rectifiers; aluminum-coated plastics—automotive interior hardware, panels, dials and trim; aluminum-coated glass—electroluminescent panels	Phonograph recording masters, surgical gauze, broadcasting transmitters, and jewelry	Thick coatings of refractory metals on wires; nickel-coated gasoline fuel delivery nozzles; and the previously impossible metallic coating of nylon and glass fibers

Organic Coatings [a]

Type →	Alkyd						Acrylic	Bituminous
	Alkyd	Alkyd-Amine	Alkyd-Phenolic	Alkyd-Silicone	Alkyd-Urea	Styrenated Alkyd		
CHEMICAL RESISTANCE								
Exterior Durability	E	E	E	E	E	G	E	E
Salt Spray	E	VG	E	E	G	G	E	E
Solvents—Alcohols	F	G	G	F	G	G	G	P
Solvents—Gasoline	G	E	E	E	E	E	G	P
Solvents—Hydrocarbons	G	E	E	P	E	E	F	P
Solvents—Esters, Ketones	P	P	F	P	P	P	P	P
Solvents—Chlorinated	P	P	F	P	P	P	P	P
Beverages, Food	F	G	VG	P	G	VG	VG	E
Salts	VG	E	E	F	E	E	VG	G
Ammonia	P	P	P	P	P	P	P	—
Alkalis [b]	G, G	VG, G	F, P	P, P	G, G	G, VG	G, F	E
Acids—Mineral [c]	F, P, P	G, F, P	VG, G, F	G, P, P	F, P, P	G, F, P	G, F, P	G, — , — [j]
Acids—Oxidizing [c]	P, P, P	F, P, P	G, F, P	P, P, P	F, P, P	F, P, P	F, P, P	—
Acids—Organic (acetic, formic, etc.) [c]	P, P, P	P, P, P	F, P, P	P, P, P	P, P, P	P, P, P	P, P, P	E, —, — [k]
Acids—Organic (oleic, stearic, etc.)	F	G	VG	G	F	F	F	E
Acid—Phosphoric	P	P	P	P	P	P	P	E
Water (salt, fresh)	F	G	E	E	F	G	E	E
PHYSICAL PROPERTIES								
Sward Rocker Hard. (8th day)	24	30	34	16	28	28	24	—
Flexibility	E	VG	G	F	VG	G	E	E
Abrasion Res, cycles [d]	3500	>5000	>5000	1000	>5000	>5000	2500	—
Max Svc Temp, F	200	250	250	1000	225	200	180	325
Toxicity	None	Slight	None	Slight	Slight	Slight	None	—
Impact Res	VG	E	G	G	E	G	E	E
Dielec Properties	G	G	VG	E	G	G	VG	—
Adhesion to—								
Ferrous Metals	E	E	E	G	E	E	VG	E
Nonferrous Metals	F	E	E	F	VG	E	VG	E
Old Paints	VG	G	G	E	G	VG	P	—
DECORATIVE PROPERTIES								
Choice of Colors [e]	U	U	SL	U	U	U	U	L
Color Retention	G [f]	VG [f]	P [f]	E [f]	VG [f]	G [f]	E [f]	—
Initial Gloss	E	E	VG	E	E	E	E	P
Gloss Retention	E	G	F	E	F	G	E	—
APPLICATION								
Ease of Application	E	Bake req	E	E	Bake req	E	VG	P-VG
Metal Surface Prep	Primer	No primer	No primer	Primer	No primer	No primer	Primer	No primer
Solvent for Appl [g]	Hyd	Hyd	Hyd	Hyd	Hyd	Hyd	Blend	—
Methods [e]	U	U	U	U	U	U	U	L
Cure [h]	A or B	B	A or B	A or B	B	A or B	A	A
Bake Drying Time [i]	30 min (275 F)	20 min (320 F)	30 min (350 F)	30 min (350 F)	20 min (320 F)	15 min (300 F)	—	—
Air Drying Times								
Touch	2 hr	—	20 min	45 min	—	10 min	5 min	2 hr
Handle	4 hr	—	60 min	2 hr	—	30 min	15 min	24 hr
Re-Coat	4 hr	—	6 hr	4-6 hr	—	4 hr	15 min	—
Hard	12 hr	—	6 hr	12 hr	—	4 hr	12 hr	24 hr
Corr Res	48 hr	—	48 hr	12 hr	—	48 hr	24 hr	—
Coverage, sq ft/gal/mil	450	450	450	500	450	400	350	—
Coat Thk (avg), mil	1.5	1.5	1.5	0.6	1.5	1.5	1.0	3-250
Cost, ¢/sq ft/mil dry [l]	1.50	1.75	—	—	—	1.75	2.75	—

[a] These data are intended only as a preliminary selection guide. Final selections should be made after consulting with coating formulator.
[b] E = excellent; VG = very good; G = good; F = fair; P = poor.
[c] Two ratings are for dilute (20%) and concentrated, respectively.
[e] Three ratings are for dilute (10%), medium (10-30%) and concentrated, respectively.
[d] Taber GS-10 wheel.
[e] L = limited (pure white cannot be formulated): SL = slightly limited (difficulty in formulating whites and pastels); U = unlimited (any color can be formulated).
Notes [f] through [l] on opposite page.

Organic Coatings [a]

Type →	Cellulose		Epoxy						Fluoro-carbon (air dried)
	Nitro-cellulose	Butyrate	Epoxy (100%)	Epoxy-Amine	Epoxy-Ester	Epoxy-Melamine	Epoxy-Phenolic	Epoxy-Urea	
CHEMICAL RESISTANCE									
Exterior Durability	E	E	G	E	G	E	E	G	E
Salt Spray	E	E	E	VG	E	VG	VG	VG	E
Solvents—Alcohols	G	G	E	E	VG	E	E	E	F
Solvents—Gasoline	G	G	E	E	E	E	E	E	F
Solvents—Hydrocarbons	F	F	E	E	VG	E	E	E	P
Solvents—Esters, Ketones	P	P	F	VG	F	VG	E	VG	P
Solvents—Chlorinated	P	P	E	E	F	E	E	E	P
Beverages, Food	P	G	E	E	VG	E	E	E	E
Salts	G	VG	E	E	E	E	E	E	E
Ammonia	P	P	P	P	P	E	VG	P	E
Alkalis [b]	P, P	P, P	E, E	E, E	E, E	E, E	E, E	E, E	E, E
Acids—Mineral [c]	G, F, P	G, F, P	E, VG, G	E, VG, G	G, F, P	E, VG, G	E, E, E	E, VG, F	E, E, E
Acids—Oxidizing [c]	P, P, P	P, P, P	G, P, P	G, P, P	F, P, P	G, P, P	E, VG, P	F, P, P	E, E, E
Acids—Organic (acetic, formic, etc.) [c]	P, P, P	P, P, P	G, F, P	G, F, P	F, P, P	G, F, P	E, E, VG	F, P, P	E, E, E
Acids—Organic (oleic, stearic, etc.)	F	F	E	E	E	E	E	E	E
Acid—Phosphoric	P	P	P	P	P	P	E	P	E
Water (salt, fresh)	F	E	VG	G	VG	G	E	G	E
PHYSICAL PROPERTIES									
Sward Rocker Hard. (8th day)	26	26	36	36	30	36	44	34	20
Flexibility	E	E	E	G	G	VG	VG, E	VG	G
Abrasion Res, cycles [d]	2500	2500	>5000	>5000	>5000	>5000	>5000	>5000	1000
Max Svc Temp, F	180	180	400	400	300	400	400	400	—
Toxicity	None	None	Slight	Slight	Slight	Slight	Slight	Slight	Slight
Impact Res	E	E	G	G	E	G	G	G	E
Dielec Properties	P	G	VG	VG	VG	VG	VG	VG	E
Adhesion to—									
Ferrous Metals	VG	VG	E	E	E	E	E	E	VG
Nonferrous Metals	G	G	E	E	VG	E	E	E	VG
Old Paints	P	P	P	P	F	P	P	P	P
DECORATIVE PROPERTIES									
Choice of Colors [e]	U	U	SL	SL	SL	SL	L	SL	U
Color Retention	E [f]	E [f]	G [f]	G [f]	E [f]	G [f]	P [f]	G [f]	G
Initial Gloss	E	E	VG	VG	E	VG	VG	VG	E
Gloss Retention	VG	E	F	F	G	F	F	F	F
APPLICATION									
Ease of Application	VG	VG	Catalyst req	Catalyst req	E	Bake req	Bake req	Bake req	VG
Metal Surface Prep	Primer	Primer	No primer	No primer	Primer	No primer	No primer	No primer	Primer
Solvent for Appl [g]	Blend	Blend	Ketone	Blend	Hyd	Blend	Blend	Blend	Blend
Methods [e]	U	U	L	L	U	L	L	L	L
Cure [h]	A	A	A	A	A or B	B	B	B	A or B
Bake Drying Time [i]	—	—	—	—	30 min (320 F)	30 min (350 F)	30 min (400 F)	30 min (350 F)	—
Air Drying Times									
Touch	5 min	5 min	45 min	45 min	1 hr	—	—	—	5 min
Handle	15 min	15 min	2 hr	2 hr	2 hr	—	—	—	15 min
Re-Coat	15 min	15 min	6–8 hr	6–8 hr	8 hr	—	—	—	12 hr
Hard	12 hr	12 hr	12 hr	12 hr	8 hr	—	—	—	12 hr
Corr Res	24 hr	24 hr	7–10 days	7–10 days	5 days	—	—	—	12 hr
Coverage, sq ft/gal/mil	200	200	450	500	450	500	450	500	200
Coat Thk (avg), mil	1.0	1.0	1.8	1.8	1.5	1.8	1.8	1.8	1.0
Cost, ¢/sq ft/mil dry [l]	2.50	2.75	—	—	1.75	—	—	2.00	15.00

Notes [a] through [e] on opposite page.
[f] Based on white coatings with titanium dioxide pigment. [g] Hyd = hydrocarbons; alc = alcohols.
[h] A = can be air dried; B = can be baked. In general, any coating that can be air dried or baked will perform better if baked.
[i] Full corrosion resistance is obtained, immediately upon cooling. [j] Not recommended with nitric acid.
[k] Not recommended with strong solutions of acetic acid.
[l] Based on high quality formulations; figures are meant to serve only as a rough guide.

continued on next page

Organic Coatings [a]

Type →	Phenolic	Polyamide (nylon)	Rubber			Silicone	Urethane	Vinyl	Vinyl-Alkyd (approx 1:1)
			Chlorinated Rubber	Neoprene	Hypalon				
CHEMICAL RESISTANCE									
Exterior Durability	E	P	E	E	E	E	E	E	E
Salt Spray	E	F	E	E	E	E	E	E	E
Solvents—Alcohols	E	G	F	E	—	P	F-G	E	G
Solvents—Gasoline	E	G	G	F	P	VG	F-G	E	E
Solvents—Hydrocarbons	E	—	P	P	—	VG	F-E	G	P
Solvents—Esters, Ketones	E	—	P	G	—	P	F	P	P
Solvents—Chlorinated	G	—	P	P	—	P	P	P	P
Beverages, Food	E	—	G	F	—	P	VG	E	F
Salts	E	—	E	E	—	G	E	E	G
Ammonia	P	G	VG	E	E	P	P	E	P
Alkalis[b]	P, P	G, G	VG, F	E, E	—	P, P	VG, F	E, E	G, P
Acids—Mineral[c]	E, E, E	P, P, P	E, G, P	E, G, P[k]	E, E, E	G, P, P	G, F, P	E, E, G	VG, G, P
Acids—Oxidizing[c]	E, E, VG	—	E, E, P	G, F, P	—	P, P, P	G, F, P	E, VG, G	P, P, P
Acids—Organic (acetic, formic, etc.)[c]	G, F, P	P, P, P	G, P, P	P, P, P	—	P, P, P	G, F, P	E, P, P	G, F, P
Acids—Organic (oleic, stearic, etc.)	E	VG	E	F	—	P	F	E	E
Acid—Phosphoric	F	—	G	VG	E	P	F	E	F
Water (salt, fresh)	E	F	VG	E	E	E	E	E	E
PHYSICAL PROPERTIES									
Sward Rocker Hard. (8th day)	38	—	24	<10	—	16	35–65	20	26
Flexibility	G	G	VG	E	E	F	E	E	E
Abrasion Res, cycles[d]	>5000	—	>5000	5000	—	2500	>5000	>5000	2500
Max Svc Temp, F	350	300	250	200	250	1200	300	180	180
Toxicity	None	—	Slight	None	—	Slight	Slight	None	None
Impact Res	G	VG	G	E	E	G	E	E	E
Dielec Properties	E	G	E	F	VG	E	E	E	G
Adhesion to—									
Ferrous Metals	E	VG	F	VG	VG	G	E	VG	VG
Nonferrous Metals	E	VG	VG	VG	VG	F	E	VG	G
Old Paints	G	—	E	—	—	E	F	G	P
DECORATIVE PROPERTIES									
Choice of Colors[e]	L	L	L	L	U	U	U	U	U
Color Retention	P[f]	—	G[f]	G	E	G[f]	G	VG[f]	E[f]
Initial Gloss	VG	G	F	P	P	E	E	G	E
Gloss Retention	F	—	F	F	—	E	P	F	E
APPLICATION									
Ease of Application	E	G	E	VG	VG	E	E	VG	VG
Metal Surface Prep	No primer	No primer	Primer	No primer	No primer	Primer	Primer	Primer	Primer
Solvent for Appl[g]	Alc	—	Hyd	Hyd	Hyd	Hyd	Blend	Blend	Blend
Methods[e]	U	L	U	U	U	U	U	L	U
Cure[h]	A or B	A	A or B	A or B	A	A or B	A or B	A or B	A
Bake Drying Time[i]	30 min (350 F)	—	15 min (300 F)	15 min (300 F)	—	1 hr (400 F)	30 min (325 F)	15 min (300 F)	—
Air Drying Times									
Touch	10 min	—	45 min	15 min	15 min	45 min	45 min	15 min	5 min
Handle	30 min	—	2 hr	30 min	30 min	2 hr	1–2 hr	30 min	15 min
Re-Coat	30 min	—	4–6 hr	4 hr	4 hr	4–6 hr	4–6 hr	4–6 hr	15 min
Hard	4 hr	—	4–6 hr	4 hr	4 hr	12 hr	18 hr	4–6 hr	12 hr
Corr Res	24 hr	—	24 hr	7–10 days	7–10 days	12 hr	5–7 days	24 hr	24 hr
Coverage, sq ft/gal/mil	350	—	450	300–400	250–350	350	—	250	200
Coat Thk (avg), mil	1.5	2–30	1.5	2–10	2	1.0	1–2	1.0	1.0
Cost, ¢/sq ft/mil dry[l]	1.75	—	1.50	—	—	6.00	—	2.50	—

Notes: See previous two pages.

Hard Facings

Hard facings (overlays applied by welding operations) are generally applied to surfaces which require high wear resistance. Service conditions which may be met, directly or indirectly, by hard facing include: **abrasion (sliding or rolling), galling, impact,** work hardening, elevated temperatures, thermal stresses, corrosion and erosion.

Types. Most hard facing alloys are proprietary alloys designed for special service conditions, but the basic types are summarized below. It can be misleading to group alloys by hardness or service use because it is primarily structure that determines their properties. Iron-base alloys, for example, can be austenitic, pearlitic, martensitic or a combination of these in the as-deposited, air cooled state. It is often difficult to determine what microstructure can be expected from a given rod.

Thickness. Thickness of hard facings ranges from 1/16 to ¼ in. depending upon the application. Parts that require a build-up greater than ¼ in. are usually given a primary layer with a lower cost material. Parts requiring extremely thin layers are generally hard faced with nickel-chomium-boron alloys which wet the base metal so readily that a uniform deposit 1/32 in. thick can be obtained.

Surface finish. Smoothness of a hard facing depends upon both material and application method. Nonferrous alloys, having more fluidity, yield the smoother deposits. Tungsten carbide rods produce a rough surface because the particles must be submerged in a matrix of softer material which wears away and exposes the rough carbide particles.

BASIS METALS FOR HARD FACING

Metal ↓	Suitability	Remarks
Low and Medium Carbon Steels	Up to 0.50 carbon steels particularly suitable	Pre- or post-heat treatment not required
High Carbon and Low Alloy Steels	Up to 1.10 carbon and 14 manganese steels are suitable if careful to prevent cracking	Annealed or as-rolled condition; generally post-heat treated
High Speed Steels	Not advisable; shrinkage cracks, strain checks	Annealed condition; post-heated and slowly cooled
High Chromium Steels	Susceptible to heat; require careful handling	Preheated to 1200 F; slow post-cooling
Manganese Steels	Difficult, due to heat disrupting grain structure. Arc welding best	Stainless steel often applied first as binding agent
Stainless Steels	Arc or gas method with care to avoid excessive strains	Parts should be preheated to temperature dependent on stainless type
Cast Irons	Difficult. White iron easy for small parts. Otherwise danger of localized overheating	Lower melting point than steel; crust forms on surface
Nonferrous Alloys	Not those with melting points below 2000 F	Monel is common and easiest; copper alloys difficult

TYPES OF HARD FACING ALLOYS

Type →	General Properties	Forms	How Applied	Typical Uses
FERROUS ALLOYS				
Hardenable. Carbon steels; low, medium and high alloy steels; high speed steels	Alloys are listed in order of increasing hardness, corrosion and impact resistance. Medium-high levels of hardness and impact resistance obtainable, but abrasion and corrosion resistance lower than in other types	Mild steel rod with alloys in flux-coating; particles in thin tubes	Arc welding (bare and flux-coated rods) or gas welding (bare rods)	Base for subsequent hard facing with other types (particularly for thick facings); rock and earth-handling equipment
Austenitic. Chromium and chromium-nickel steels; high manganese steels; high chromium irons; high alloy irons	Provide principally austenitic deposits (except some straight chromium steels) hardenable by cold work. Fair degree of hardness with good impact and abrasion resistance extending into elevated temperatures	Cast rods	Arc welding (bare and flux-coated rods) or gas welding (bare rods)	Crushing equipment; such earth-moving equipment as bucket lips, crusher rolls and muller tires; plowshares
NONFERROUS ALLOYS				
Cobalt-base. Medium carbon; high carbon	High corrosion resistance, good abrasion and impact resistance. Hardness less than high ferrous alloys but retained at elevated temperatures ("red hardness")	Solid rods cast in permanent or sand molds	Gas welding (use of torch is similar to brazing)	Valves, pump parts, dies; large areas where hairline cracks not permissible
Nickel-base. Nickel-chromium; nickel-chromium-tungsten molybdenum	Excellent heat and corrosion resistance, fair abrasion and impact resistance. Hardness is less than high ferrous alloys but retained at elevated temperatures ("red hardness")	Solid rods cast in permanent or sand molds	Gas welding (use of torch is similar to brazing)	Very thin sections; parts which must be hot formed or hot wiped; substitute for tungsten carbide rods
Intermetallics. Tungsten carbides; thers	Maximum hardness with excellent resistance to impact and corrosion. Despite brittleness, carbides have excellent resistance to fracture when backed up with steel.	Cast rod; particles in thin tube; powder; inserts	Rods by gas or arc; powder by spraying; inserts by "puddling"	Oil well drilling tools; mill hammers, augers, dipper bucket teeth and lips, mixing plows

Ceramic, Cermet and Refractory Coatings

Type ↓	Important Properties
Mixtures of Porcelain Enamel Frits and Refractory Materials	
NBS[a] A-19	Prevents oxidation of noncritical steels at high temp. Protects low carbon steel to 1250 F and high temp austenitic alloys to 1550 F
NBS A-31	Similar to A-19 coating but, since it must be applied in two coats, is only used for specialized applications
NBS A-417	Protects noncritical steels against high temp oxidation. Has been largely supplanted by A-418 coating
NBS A-418	Widely used to extend life of heat resisting steels such as Inconel, Inconel X, Nimonic 75, HS-21 and 18-8, 19-9 and 25-20 stainless steels. Protects up to 1750 F. Not recommended for low carbon steels
NBS N-143	Has low absorption coefficient for thermal neutrons and is designed for nuclear applications. Protects 310 stainless, Nichrome V and Inconel against oxidation up to 2050 F
Proprietary Coatings for:[b]	
Low Carbon and Low Alloy Steels	Improves oxidation and corrosion resistance to 1400 F
300 and 400 Stainless Steels	Extends service life of most alloys up to 1800 F. Special formulations protect against unusual abrasive or corrosive attack up to 2000 F
Aluminum	Extends operating temp of standard and some high strength alloys up to 1550 F
Titanium	Allows use of titanium up to 1500 F
Thin-Gage Metals	Protects foils 1 to 10 mils thick at temp up to 1750 F. Used on 300 and 400 stainless steels and superalloys
Extra High Temperatures	Special coatings for use up to 2100 F. Can be used on all alloys containing 45% of the combination of chromium (10% min), cobalt and nickel
Resistance to Galling	Provides low friction and prevents galling at temp from 800 to 1650 F. Can be used on all ferrous (and some nonferrous) alloys
Pure Refractory Oxide Coatings	
Aluminum Oxide (Alumina)	Provides high resistance to wear and abrasion, good thermal insulation, and high resistance to oxidation (3600 F melting point). Can be applied by variety of methods (e.g., flame spraying, Flame-Plating and plasma jet) to almost every ferrous and nonferrous metal, as well as some plastics and other non-metallic materials
Zirconium Oxide (Zirconia)	Because of higher melting point (4500 F) can be used at higher temp than alumina. However, is not as hard or as resistant to abrasion as alumina. Can be used on same materials as alumina
Cermet Coatings[c]	
Aluminum-Ceramic	Composed of a mixture of aluminum alloy powder and ceramic frits. Can be applied to carbon steels, low alloys and cast iron for oxidation protection to 1200 F. Has high resistance to thermal shock and impact
Chromium Carbide (flame sprayed)	High resistance to abrasion and oxidation up to 2900 F. Can be ground to smooth finish
Chromium Carbide (chromized)	Provides hard and wear resistant case on low carbon steels, many alloy and high chromium steels, and iron powder parts
Chromium-Nickel Boride	Protects iron and steel against attack by molten aluminum. Good resistance to thermal shock
Molybdenum Disilicide	Provides good oxidation resistance to 2900 F. Coating is brittle but this may not be important in non-structural uses
Nitrided Surfaces	Essentially, nitriding provides a cermet coating. Process is limited to certain grades of steel and forms an extremely hard case which retains hardness up to 1100 F and is not subject to fatigue
Silicon Carbide	Improves erosion resistance of graphite up to 4000 F. Highly resistant to acids and alkalis
Tungsten-Carbon and Tungsten-Boron	High density (0.53 lb per cu in.) is useful in increasing weight in restricted places
Tungsten Carbide	Provides extreme hardness and wear resistance. Can be applied to almost all metals
Other Refractory Coatings[d]	
Aluminum Silicate (mullite)	Protective coating for graphite
Iron Titanate	Similar to titanium dioxide in properties, but coating is softer and hence less useful
Iron Titanate: Gamma Aluminum (50:50)	Coating is conductive and has melting point of 2500 F. Not widely used
Titanium Dioxide	Provides hardness and wear resistance. Coating is tough, has excellent adhesion and is not brittle
Zirconium Silicate	Provides high hardness and resistance to wear, corrosion and thermal shock. Coating is nonconductive and has good adhesion

[a] National Bureau of Standards.

[b] Many of these coatings are variations of NBS coatings. Coatings described are typical; many others are available for other base metals and special applications.

[c] In addition to the coatings described, recent announcement has been made of a number of other cermet coatings which can be applied by the plasma jet process. These coatings include refractory carbides of columbium, hafnium, tantalum, zirconium, titanium and vanadium. As of spring, 1959, these coatings are still largely in the experimental stage and little information is available on properties and applications. Molybdenum aluminide and nickel aluminide cermet coatings and rare earth (50% cerium oxide) refractory coatings can be applied by flame spraying but they do not appear to have any useful properties.

[d] In addition to the coatings described, a number of other refractory coatings can now be applied by the plasma jet process. These coatings are still experimental and property data is not yet available. The coatings encompass a wide variety of materials, including: 1) refractory oxides of thorium, hafnium, magnesium and cerium; 2) refractory metal compounds, such as borides of zirconium, tungsten, columbium, tantalum, titanium and chromium; 3) refractory metals, such as tungsten, tantalum, molybdenum and rhenium.

Mechanical Finishes for Aluminum, Copper and Stainless Steel[a]

Type ↓	Appearance	How Finish Is Obtained[b,c]	Uses
Smooth Bright (buffed)	Brightest mechanical finish. Surface is smooth and lustrous, can be made mirror-bright by using fine abrasive, electro-brightening in final polishing, or (on Al) chemical brightening. Cu must be plated or clear-lacquered to preserve appearance	Two or three buffing operations (with progressively softer buffs and/or finer compound) following polishing or other finishing operations. Skilled operator needed to prevent buff-burned or pitted surfaces. Approx buffing wheel speeds: stainless 10,000; Al 8000; Cu 6–10,000 sfpm. Al usually given light caustic etch between buffing steps to remove embedded particles	For attractive appearance or high reflectivity. Usually economically feasible only for larger items or close tolerance parts. Examples: household appliances, sanitary equipment, auto and boat trim, light reflectors, jewelry, small objects d'art. Also for Al before anodizing
Smooth Bright (burnished)	Not as bright as buffed surface esp if surface has retained oxide coating or has not been machined. Brightness depends on treatment time and relative movement and pressure of burnishing media	Gentle tumbling in barrel with stainless steel balls 1/16–½ in. in dia and neutral soap solution (+ soap bark for Cu).[d] Time required: stainless, 1-4; Al, 1½–2½; Cu, 6–48 hr. Hard to get uniform finish on complex-shaped parts	Similar to above, but generally smaller, mass-produced parts or parts difficult to buff. Examples: pen points, eyelets, grommets, auto trunk locks, auto push-buttons
Satin Semi-Bright (wheel or belt polished)	Smoothest sheen of the satin finishes because of finer, more irregular scratches. Brightness depends on fineness of abrasive in final operation. Tampico brush wheels produce slightly duller surface	Several polishing operations following grinding.[e] Wheels may be fabric, felt or leather. Lubrication usually required in wheel polishing with finer abrasives; belts reduce danger of overheating. Approx speeds: stainless 4500–7500, Al 5–6000, Cu 6–9000 sfpm. Abrasive usually alumina or silicon carbide (neither emery nor silicon carbide recommended for stainless). Preliminary polishing of Cu often done by sand-bobbing (using abrasive and wheel wet with mineral oil)	Parts where attractive, low reflection finish is desired. Examples: dairy, bar and cafeteria equipment; utensils; auto and furniture handles, knobs, rosettes. Also to prepare for finer finishes
Satin Semi-Bright (wire brushed)	Smooth sheen; smoothness dependent on wire size (thinnest wire for smoothest finish). Usually brighter than satin finish produced by polishing	Wire brushing of low polished surface entirely free of grease or oil. Brushes usually 10 in. in dia. Low pressures used. Wheel speeds from 2000 rpm for polished sheet to 600 rpm for castings (castings usually dustblasted or medium sandblasted before brushing). Nitric acid dip may be used after brushing to dissolve embedded particles	Same as above. Widely used on Al, sometimes on Cu. Not used on stainless because of its hard surface
Textured Semi-Bright (hammered)	Decorative finish somewhat similar to wrought silver. Minor scratches and defects obscured	Hammering by hand. Parts may be heated in smoky fire and hammered until soot is embedded; polishing of high spots then produces special decorative effect	Used on Al and Cu. Examples: architectural and commercial products, giftware, novelty items
Textured Semi-Bright or Matte (embossed or engraved)	Patterned finish having wide variety of decorative effects	Sheet passed between embossing rolls or pantograph-engraved; recesses may be filled with enamel for contrast and decoration. Applied to polished, buffed, satin finished, sandblasted (Al) or vapor honed (stainless) surfaces	Decoration and increase in rigidity. Limited to flat work. Examples: building panels, doors, nonskid surfaces, auto trim, plaques, tablets, nameplates
Textured Matte (sandblasted)	Special decorative effects, esp by combination with other processes. Surface texture depends on size and type of abrasive, amount of air pressure, and movement and angle of nozzle. Surface collects dirt unless protected, as by clear lacquer	Spraying surface with fine abrasive or slurry by air pressure. Careful control of nozzle is needed for desired effects and to prevent distortion. Contrasting surfaces obtained by enameling, anodizing, blackening, highspot polishing, caustic etching, etc.	Primarily for Al.[f] Examples similar to above; not limited to flat pieces

[a] Including aluminum and copper alloys.
[b] Stainless steel can be purchased with a number of different mill finishes. The bright cold rolled finish is usually specified for subsequent polishing or buffing. If severe forming is to be done, dull cold rolled may be preferable. Higher mill finishes available include polished, Tampico brush-finished and semi-mirror-finished.
[c] Aluminum mill finishes include a variety of embossed designs and a fluted finish.
[d] Another tumbling process—with granite chips, alumina or silica sand—is used to deburr and smooth stainless and aluminum parts, but does not produce as bright a surface and is not recommended for close tolerance parts.
[e] On aluminum, a somewhat brighter surface can be obtained by further finishing with steel wool and kerosene; a somewhat duller surface by low or coarse polishing followed by rubbing with steel wool and soapy water.
[f] Special effects on copper often achieved by engine turning. Stainless is usually vapor honed.

Porcelain Enamels

Composition

Porcelain enamels are inorganic glass coatings for metal that are formulated for specific applications. They are characterized by easy-to-clean, smooth, hard, lustrous surfaces that are resistant to attack by chemicals, heat and mechanical abrasion. They embrace a wide variety of compositions, all of which are similar in that they consist essentially of a glass matrix (usually alkali borosilicate) in which may be suspended crystalline opacifiers and pigments. When appreciable quantities of refractory compounds, such as alumina, chromic oxide or silica, are incorporated to increase heat resistance, these special porcelain enamels are termed ceramic coatings.

Conventional porcelain enamels for steel comprise one, two or three layers. The first layer is a dark colored 3 to 4-mil "ground coat" (analogous to an organic primer) containing an oxide of cobalt or nickel that promotes good adhesion to the steel. On other metals, where the oxide need not be present, the ground coat may be light colored or white. In addition to promoting adhesion, the ground coat also tends to cover or hide certain defects in the metal and on the metal surface. Where appearance is not important, the ground coat is frequently used as a single protective coating. Some of the single-coat porcelain enamels (the gray or speckled types) are attractive. They can also be made alkali resistant.

Ordinarily, one or two 3 to 5-mil layers of "cover coat" are applied to achieve a desired appearance or protection property. Two general types of cover coat are used: opaque white and non-opaque. Titanium dioxide, the opacifier used in most opaque white cover coats, is incorporated in the glass and crystallizes during the firing operation. It provides the high covering power that makes possible satisfactory coverage with a single 3 to 4-mil top coat. The oxides of tin, antimony and zirconium are also used as opacifiers, but to a lesser extent than titania.

Base Metals

Porcelain enamels can be applied to most metals and alloys provided the metal remains solid at the firing temperature and does not oxidize excessively during firing. Because fusion is accomplished at high temperatures and involves cooling over a fairly large temperature range, the coefficient of thermal expansion (or contraction) of the porcelain enamel should be slightly lower than that of the metal to which it is applied. This assures that the coating will be under compression at the operating temperature of the coated part. Compression is desirable because the coating, being a glass, has about ten times the strength in compression that it has in tension.

In addition to most ferrous alloys, porcelain enamels can be applied to gold, silver, platinum, copper, aluminum and superalloys. The more commonly used metals are:

Enameling iron. Low carbon, low metalloid, rimmed steel, specifically designed and specially processed for porcelain enameling. It is produced in sheets of various gages from about 30 to 11, and in two grades: regular and deep drawing. It has good resistance to sagging and distortion during firing of the porcelain enamel and produces a minimum of surface defects in the coating.

Cold rolled mild steel. Low carbon rimmed steel sheets (usually AISI 1008 or 1010) of good surface quality, available as commercial and deep drawing grades. This metal is subject to more warping during firing than enameling iron and is more likely to produce defects in the coating. For these reasons porcelain enamels applied to cold rolled mild steel are usually fired at temperatures below 1450 F.

Hot rolled steel plate. Hot rolled, low carbon steel plates of heavy gage are used primarily in the fabrication of domestic hot water tanks and other structures requiring strength and corrosion resistance. This metal is not suited for parts where appearance properties are of vital importance.

Special enameling steels. Special steels of low metalloid content specially processed to accept porcelain enamel cover coats without the use of a ground coat. One type has an extremely low carbon content (0.003% or less) and another is titanium-bearing.

Cast iron. Gray iron castings of the following composition: 2.50 silicon, 3.00 carbon, 0.70 phosphorus, 0.60 manganese, 0.08 sulfur and 0.40% combined carbon. Must have reasonably dense and uniform structure and must be free from porosity, slag inclusions and segregation.

Aluminum. Wrought and extruded alloys include: 1100, 3003, 6061, 6062, and 6063. Cast alloys include: 43, 356 and 344X. In selecting aluminum alloys for porcelain enameling, it should be remembered that maturing temperatures of the coatings are above the annealing temperatures of the "common" alloys.

Aluminized steel. Combines strength, rigidity and sag resistance of steel with many of the advantages of aluminum.

Stainless steel. Important base metal for ceramic coatings for parts operating at temperatures up to 1200-1800 F. The 300 and 400 series are most commonly used.

Appearance Properties

Color. Although certain colors are more difficult or expensive to control during application, the full spectrum of colors, including white and black, can be produced. Burgundies, purples and certain shades of orange and red are most difficult to control in production. Pigmenting materials are inorganic metallic compounds known as "ceramic oxides." Because they are chemically and thermally stable, they contribute to the color permanency associated with porcelain enamels.

Metallic lusters, such as copper, bronze, gold and platinum, can be produced, but are usually restricted to small patterns or designs.

Texture. Textural appearances available are best described by the method of producing them. These decorative processes include stippling or speckling, veiling, polytoning, graining and marbleizing, stenciling, printing, silk screening and decalcomania.

Opacity. The reflectance of white porcelain enamels ranges from 60 to 90%, as compared to 100% for magnesium oxide (ASTM Method C347 for Reflectance). Many tints of white extending into light pastels are also available.

Application Methods

Wet process. Simply stated, porcelain enameling is the process of re-fusing powdered glass into a continuous layer on the surface of a metal. In the wet process, water is used as a vehicle to facilitate application of the powdered glass. The mixture of solid

particles suspended in water, called a slip, can be applied by any of the methods used for organic coatings: spraying, dipping or flow coating. After the liquid slip is applied, water is removed by drying. The film of dry particles on the metal is then fused by heating for a short time at the temperature established for the particular coating composition involved.

Firing temperatures range from 1000 F, or below, for porcelain enamel on aluminum, up to 2000 F, or above, for some ceramic coatings applied to high temperature alloys. Porcelain enamels applied to sheet steel are fired at about 1350-1600 F. Most ground coats are fired at 1450-1550 F; most cover coats at 1400-1500 F. The ground coat is usually fired at a temperature 25-50 F higher than the temperature at which the cover coat is to be fired, although a number of specific ground-and-cover-coat combinations have been developed in which ground-coated and cover-coated pieces can be fired at the same temperature. Wet process cast iron and some new low-firing porcelain enamels for steel mature at temperatures as low as 1200 F. Some chemically resistant porcelain enamels (called glass coatings) are fired at temperatures as high as 1650 or 1700 F.

Dry process. Used primarily for heavy sections of cast iron or steel plate. The bare shape is heated to about 1700 F and then removed from the furnace. The porcelain enamel, in the form of a fine dry powder, is sprinkled on the hot surface. The coated piece is returned to the furnace to complete fusion of the porcelain enamel and to produce the very glossy, fire-polished surface that is characteristic of this process. A high degree of skill is required.

Chemical Properties

Acid resistance at room temperature. Porcelain enamels are tested for acid resistance at room temperature by the standard Porcelain Enamel Institute Test, PEI T-7 (ASTM C282). A porcelain enameled specimen is exposed to a 10% solution of citric acid for 15 min. The enamel is rated on the basis of the appearance of the treated area and the extent to which it retains soil. Ratings are: Class AA (no attack), A, B, C and D (complete loss of gloss).

Boiling acid resistance. Resistance to attack by boiling acid is evaluated in terms of weight loss per unit area produced by 2½-hr exposure to a boiling 6% solution of citric acid (ASTM C283).

Mineral acid resistance. Special porcelain enamels can be formulated to be resistant to attack by any mineral acid (except hydrofluoric) at any concentration and at temperatures up to the atmospheric boiling point of the acid.

Weather resistance. All porcelain enamels give excellent protection against corrosion if coverage is complete before installation, and if no severe mechanical damage occurs. For best resistance to loss of gloss and color change during prolonged weathering, only those porcelain enamels should be used that pass the acid resistance test described in the Porcelain Enamel Institute Specification for Architectural Porcelain Enamels on Steel for Exterior Use (PEI S-100). Most such porcelain enamels have acid resistance of Class A or better.

Certain red and yellow acid-resisting porcelain enamels containing cadmium-selenium pigments may fade on prolonged exposure to weather. A copper sulfate spot test (described in PEI S-100) can be used to select red and yellow porcelain enamels that are free from such fading.

Alkali resistance. All porcelain enamels are highly resistant to attack by alkaline solutions at room temperature; all porcelain enamels are strongly attacked by boiling concentrated caustic solutions. Special porcelain enamels are available that have excellent resistance to attack by hot dilute alkaline solutions, such as detergents.

Thickness

Thickness of most porcelain enamel finishes will be in the following range:

Porcelain Enamel	Thickness Range, mils
One Coat on Steel	3-8
Normal Two Coats on Steel	7-11
Multicoat Finishes on Steel	11-25
Wet-Process Cast Iron	10-25
Dry-Process Cast Iron	25-70
Aluminum (1 or 2 coats)	2-10
Stainless Steel	2-10
Copper	2-20

Multicoat finishes are required for brilliant or saturated colors. Whites or pastel colors can be produced in one or two coats.

Physical and Mechanical Properties

Abrasion resistance. Porcelain enamels combine a Mohs hardness of 4 to 7 with an exceptionally smooth surface, resulting in good resistance to abrasion and mechanical wear. Abrasion resistance of a porcelain enamel is evaluated by a standard test, PEI T-2 (ASTM C448-59T).

Torsion resistance. Torsion resistance is evaluated by twisting a porcelain enameled metal angle until the coating fails by chipping along the apex (PEI T-5; ASTM C409). Values for a 12-in. long angle vary from about 30 deg for heavy coatings to over 180 deg for thin one-coat finishes.

Adherence. Degree of bonding between the porcelain enamel and the underlying metal is evaluated by subjecting a specimen to a controlled severe deformation that fractures the coating. Adherence is evaluated in terms of the percentage of the deformed area to which the coating adheres after the treatment (PEI T-17; ASTM C313).

Thermal shock resistance. Porcelain enamels are normally unaffected by very fast heating, but may be damaged by very rapid quenching from high temperatures. In general, thin coatings have greater thermal shock resistance than thick coatings. Very thick coatings may fail when immersed in ice water from a temperature of 300 F; thinner coatings may be undamaged when quenched from 800 F. Ceramic coatings have been quenched repeatedly from 1600 F without damage.

Heat resistance. Most porcelain enamels are viscous at their firing temperatures. The upper temperature limit for prolonged exposure is about 400 °F below the firing temperature, although this temperature can be exceeded for brief periods without damage. The upper temperature limit for prolonged service will vary from about 600 F for porcelain enamels on aluminum to 1100 F for some porcelain enamels on steel. Ceramic coatings have been developed for temperatures above 2000 F.

Chemical Conversion Coatings

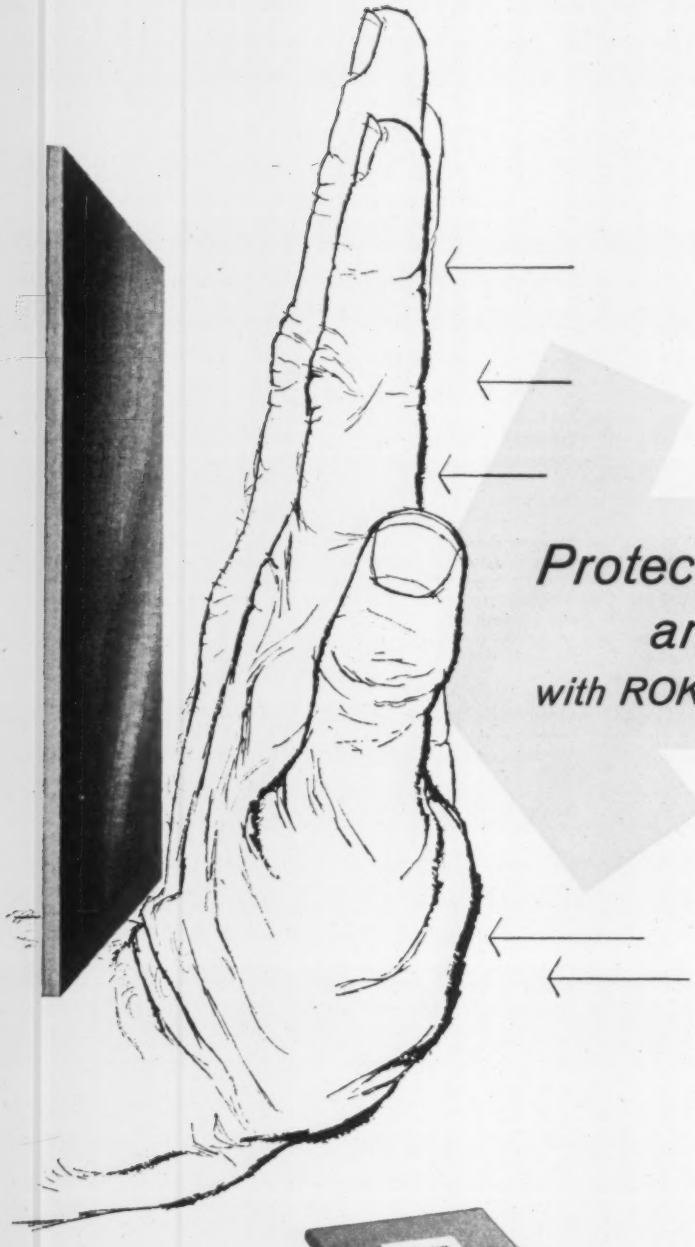
Purpose and Type ↓	How the Coatings Compare	Metals That Can Be Coated[a]									
		Aluminum	Cadmium	Copper	Iron	Magnesium	Silver	Steel	Tin	Titanium	Zinc
To Improve Paint Bonding											
Phosphate	Rough crystalline structure provides excellent paint adhesion. Better paint bond than chromate coatings. Corrosion confined to limited area when paint film damaged	X	X		X	O		X	O		X
Chromate	Provides high corrosion protection because of nonporous structure. Paint adhesion generally not as good as with phosphate	X	X	O		X	O				X
To Improve Corrosion Resistance											
Anodic	Provides equal or better corrosion protection—at higher cost—than chromate	X				X					O
Chromate	Generally provides much better corrosion resistance than phosphate. Nonporous structure acts as moisture barrier. If coating is broken, inhibiting action of soluble chromate retards corrosion of basis metal	X	X	X		X	O				X
Phosphate	Not generally used alone for corrosion protection. When treated with oils, waxes or stains, however, it provides good protection, especially on ferrous surfaces	X	O		X			X	O		X
Oxide and Other	Do not provide as much protection as other conversion coatings, but cost is lower	O	O	O	O			O			O
For Decoration											
Chromate	Available in wide variety of natural and dyed colors. Colors are not as light-fast as in colored anodic coatings	X	X	X		X					X
Anodic	Can be colored with a large variety of dyes and pigments. Underlying metal can be used to impart attractive metallic sheen. Sealing required	X				X					O
Phosphate	Little decorative value except when painted	X	X		X	O		X	O		X
Oxide and Other	Black and blue-black coatings widely used to decorate ferrous, zinc and cadmium surfaces. Considerable number of colors producible on copper and aluminum	X	X	X	X			X			X
To Aid In Cold Forming											
Phosphate	By preventing metal-to-metal contact, lubricated coating facilitates deep drawing, cold heading, extrusion, and wire and tube drawing	X			X			X			X[b]
Oxide and Other	Special coatings have been developed for titanium									X	
To Improve Wear Resistance											
Phosphate	Maintains continuous oil film between bearing surfaces; prevents welding of surfaces under load				X			X			
Anodic	Hard anodic coating with greater thickness and weight than conventional anodic coatings increases wear and abrasion resistance	X				X					

[a] X—Metals most commonly treated for purpose listed. O—Metals less commonly treated. [b] Electroplates.

Preplated and Precoated Metals

Surface and Coating Method ↓	Base Metal		Critical Functions, Properties	Typical Applications
	Metal	Form		
Aluminum (hot dipped)	Low carbon steel or copper-bearing	Sheet, strip	High heat reflectivity. High temperature oxidation resistance. Forms refractory alloy at 1000 F. Strong, low cost base	Oven door liners, aircraft firewalls, auto mufflers, broiler and toaster parts, baffles for space heaters, jet engine parts
	Steel (ASTM A122)	Strand (7-wire)	Galvanic protection. Strong base. Longer life than zinc-coated steel	Guy wires, span wires, overhead ground wires
Brass, Copper (plated)	Low carbon steel	Sheet, strip	Decoration. Atmosphere resistance. Good solderability	Luggage, hardware, costume jewelry, tubing, frames, stands
	Zinc	Sheet, strip	Decoration	Molding, ornaments, trim, badges, buttons
Bronze[a]	Low carbon steel	Strip	Decoration. Atmosphere resistance. Strong base. Conserves copper	Ornamental trim, shell cases
Chromium[b] (plated)	Aluminum, brass, copper, zinc	Sheet, strip	Decoration	Toys, reflectors, trim, signs, auto accessories
	Low carbon steel	Sheet, strip	Decoration, atmosphere resistance	Heater and toaster shells, tubes
Lead[c] (plated)	Low carbon steel	Sheet, strip	Atmosphere resistance. Good solderability, drawability	Telephone cable sheathing, containers
(plated or hot dipped)	Copper (ASTM B101)	Sheet, strip	Atmosphere resistance	Roofing, flashing
(hot dipped)	Low carbon steel	Sheet, strip	Atmosphere resistance. Good solderability, drawability. Paint base	Ammunition boxes, ducts
Terne[d] (hot dipped)	Low carbon steel	Sheet	Atmosphere resistance. Good solderability, drawability. Paint base	Gasoline tanks, caskets, paint and oil containers, door frames
Nickel[e] (plated)	Low carbon steel	Sheet, strip	Decoration, atmosphere resistance	Toys, nameplates, trays, knives
Tin (plated)	Low carbon steel	Sheet, strip	Resistance to atmosphere, chemicals. Good solderability. Strong, low cost base	Food product cans, kitchenware, bearings (babbitting base), parts to be soldered
(hot dipped)	Low carbon steel	Sheet, strip	Same as above	Tin cans for food products
Zinc (plated)	Low carbon steel	Sheet, strip, flat wire	Atmosphere resistance. Galvanic protection. Strong, low cost base	Lighting fixtures, refrigerator parts, spools and reels, oil cans, signs
(hot dipped)	Low carbon steel (incl ASTM A123)	Plate, bar, sheet, strip, shapes	Same as above	Agricultural, refrigerator and air conditioning parts, auto mufflers
	Carbon or low alloy steel (ASTM A53)	Tubing, pipe, conduit	Same as above	Water pipe. Electrical and hot air conduits
	Low carbon steel	Wire	Same as above	Fencing
Alkyd Baking Enamel	Low carbon steel, aluminum	Strip	Decoration, atmosphere resistance	Venetian blinds, auto dashboards, lighting fixtures, awnings
Polyvinyl Chloride	Steel, aluminum, magnesium	Sheet, strip	Decoration. Resistance to atmosphere, chemicals. Abrasion resistance. Formability. Low cost base	Business machine housings, auto panels, television cabinets, air conditioner housings
Vinyl Lacquer or Enamel	Low carbon steel, aluminum, brass, zinc	Strip	Decoration. Atmosphere resistance. Formability	Caps, lipstick cases, garden tools, toys, eyelets, flashlight parts
Other	Steel, aluminum, brass, zinc	Strip	Same as above	Toys, reflectors, brackets, frames, caps, movie reels, ashtrays, auto moldings and trim, novelties

[a] 90–10. [b] Over nickel. [c] Sometimes over copper. [d] 75–85% lead. [e] Over copper.



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MUTUAL® CHROMIC ACID	**Uses:** Chromium plating. Anodizing of aluminum to resist corrosion. Pickling and bright dipping of copper, copper alloys, zinc, cadmium, aluminum, magnesium. Active ingredient in chromate conversion coatings. Packaged in Steel Drums.
MUTUAL SODIUM BICHROMATE	**Uses:** Pickling and bright dipping of copper, copper alloys, zinc, cadmium, aluminum, magnesium. Active ingredient in chromate conversion coatings. Packaged in Paper Bags, waterproof Burlap Bags, Fiber Drums, Steel Drums, Tank Cars, Tank Trucks.
MUTUAL POTASSIUM BICHROMATE	**Use:** Active ingredient in chromate conversion coatings. Packaged in Paper Bags, Fiber Drums, Steel Drums.
METHYLENE CHLORIDE	**Use:** A most effective paint stripper. In specialized solvent-type formulations, quickly and thoroughly removes caustic-resistant organic finishes from wood, aluminum, etc.
SOLVENTS	**Methylene Chloride** (Also see above). Non-flammable. Low in toxicity. Used to dilute flammable solvents to raise flash points into the safety zone. Used with an evaporation retardant for cold dip degreasing of metal parts. Packaged in Drums, Tank Cars. **Carbon Tetrachloride.** Solvent for metal degreasing. Non-flammable. Packaged in Tank Cars, non-returnable Rheemcote Lined Drums. **Chloroform.** Non-flammable solvent. Packaged in Tank Cars, non-returnable Drums. **Monochlorobenzene.** Solvent of moderately high flash point. Packaged in Steel Drums, Tank Cars, Tank Trucks. **Ortho-dichlorobenzene.** Solvent of moderately high flash point. Packaged in non-returnable Steel Drums, Tank Cars, Tank Trucks.
SODIUM NITRITE	**Uses:** Forms an invisible, water-soluble gamma oxide protective film that guards metal surfaces against corrosion. Used with nitrates for heat treating metal. Low melting point. Used with caustic soda for blackening steel. Oxidizing agent. Packaged in Barrels, Steel Drums, Bags, Tank Cars.
HYDROGEN PEROXIDE	**Uses:** Used as a depolarizer, to remove hydrogen gas from metal surface. Used in metal salt solutions to purify. Removes iron in nickel plating. Cleans, brightens metal surfaces. Oxidizing agent for phosphate coatings. Oxidizing agent for zinc phosphate baths. Removes iron. Packaged in returnable Aluminum Drums, Tank Cars, Tank Trucks.
METHYL CHLORIDE	**Use:** In metal annealing salt baths, assists in dissolving oxide impurities. Packaged in pressurized Tank Cars.

Allied Chemical

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SOLVAY branch offices and dealers are located in major centers from coast to coast.

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(list products and uses that interest you)

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Photograph of the cupric oxide needles (magnified 6500x) produced by immersion of copper part in hot solution of Ebonol "C" Special.

Treating copper and brass surfaces with Ebonol "C" Special will insure high adhesion for almost every type of coating. This patented product of Enthonics Research forms thousands of jet black cupric oxide needles per square inch. Once these needles become imbedded in the coat or adhesive, and the coating sets, adhesion is tight and long-lasting. Lacquers, enamels and plastics are all bonded firmly to copper or brass surfaces when these surfaces have been pre-treated with Ebonol "C" Special.

Use Ebonol "C" coatings to achieve extremely low reflectivity on military equipment and optical parts. The coatings absorb oil, giving better lubrication of copper surfaces. They resist corrosion and produce an attractive finish with little dimensional change. Heat radiating and absorbing abilities of the surface are increased. Printed circuit manufacturers oxidize copper foil in Ebonol "C" Special before coating with adhesive and bonding to the plastic laminate. Result: double the bond strength.

Write for the complete story on Ebonol "C." We promise it will be immediately rewarding. Enthone, Incorporated, 442 Elm Street, New Haven, Connecticut.

ASARCO

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Flame sprayed metal increases wear resistance better than 10 times

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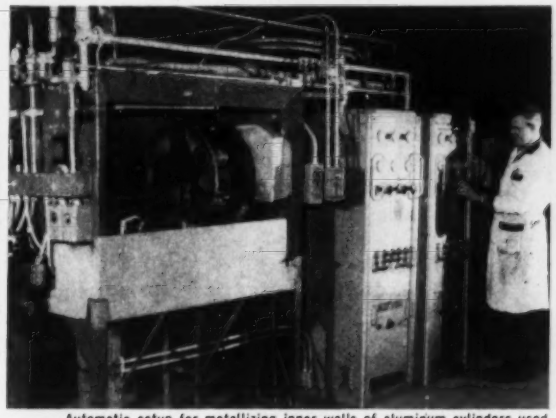

Automatic setup for metallizing inner walls of aluminum cylinders used in lightweight gasoline engines. Cabinet in foreground houses six-station rotary setup; automatic control panels are at right.

Many methods, including cast-iron cylinder liners and chrome plating, have been tested for wear resistance in lightweight gasoline engine blocks of aluminum.

Best of these methods experienced breakdowns in less than 400 hours. Now they are metallized with METCO Sprabond (molybdenum alloy) as a bonding agent, followed by a coating of sprayed steel alloy.

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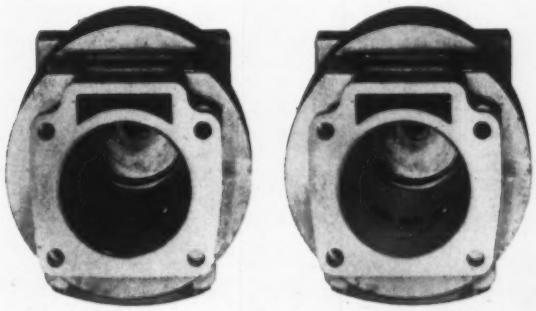
Closeup of automatic six-station rotary setup. Cylinders are individually rotated at 150 rpm. Cylinder is loaded on table at Station 1, moved through Stations 2 and 3 for pre-heating by torch. At Station 4, bonding coat is applied by the gun nozzle which feeds into the rotating cylinder. Low alloy steel is applied at Station 5 and cylinder cools at Station 6. Cylinder walls are finished by honing.

New engineering data bulletin

Bulletin 136B—The METCO Flame Spraying Processes, provides basic engineering and application data on flame sprayed coatings of metals, ceramics, carbides and other high melting point materials. 16 pages. Send coupon for free copy.

Cylinder at left machined ready for flame spraying; one at right has been metallized and hone finished.



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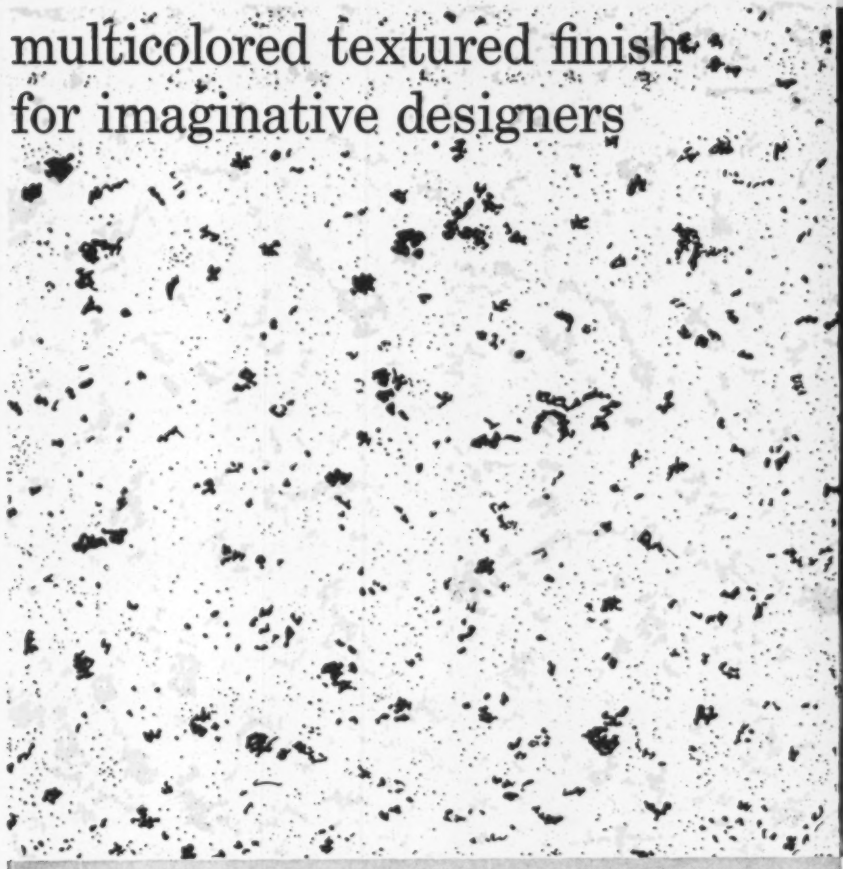

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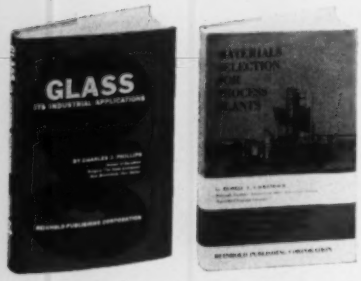
COVERS THE MANUFACTURE, physical and chemical properties, and the industrial applications of all types of glass. It is directed to the users—engineers, scientists, production and purchasing personnel—who are involved in the design, specification, testing, purchase or sale of glass products. The book reflects all the recent advances in the field and includes new information on such subjects as glass bead reflectorization and the "floot glass" process for making flat glass. The order of topics has been arranged for maximum continuity so that each topic is preceded by everything needed to understand it. Here is a thorough, semi-technical approach to the subject which provides an up-to-date treatment of all phases of the manufacture and use of glass.



Covers metals, plastics, rubber, paints and cements . . .

2 MATERIALS SELECTION FOR PROCESS PLANTS

by RUSSELL E. GACKENBACH, *Materials Engineer, Engineering and Construction Division, American Cyanamid Company*

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THIS PRACTICAL HANDBOOK goes directly to the problem of material selection as encountered by the engineering, maintenance and production personnel of process plants. The book contains all necessary data on metals, plastics, rubbers, paints and cements. The author discusses corrosion-resisting qualities along with the mechanical properties and fabricating characteristics that must be considered in selecting the most suitable and most economical material for a particular purpose. The information contained in the book is presented in non-technical terms to be of the greatest use to that large group responsible for obtaining longer production runs, increased down time, and decreased maintenance and engineering costs.

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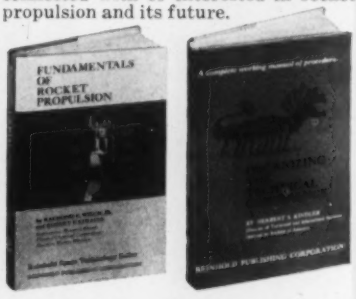

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4 ORGANIZING THE TECHNICAL CONFERENCE

by HERBERT S. KINDLER, *Director of Technical and Educational Services Instrument Society of America*

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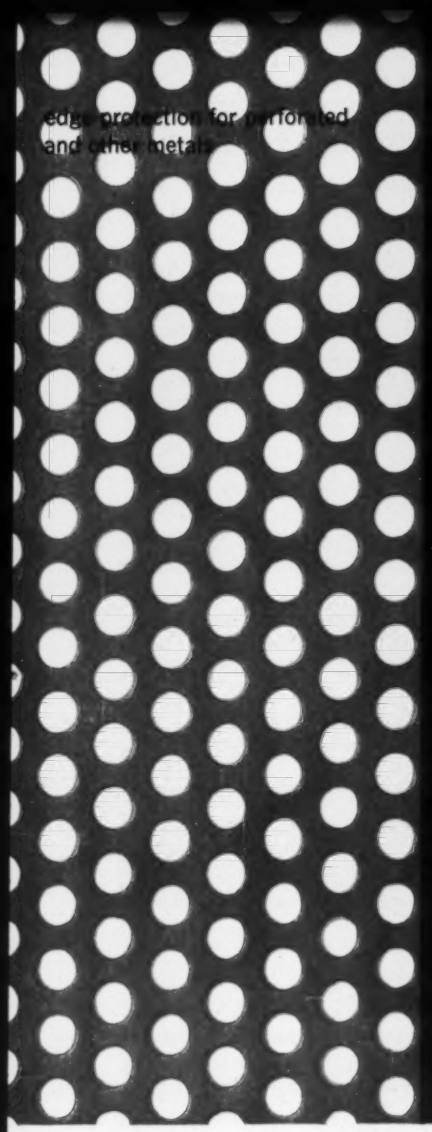

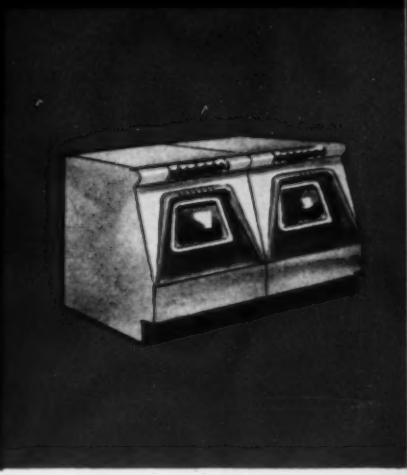

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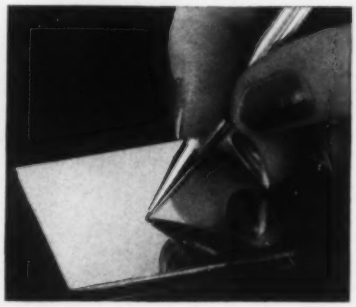
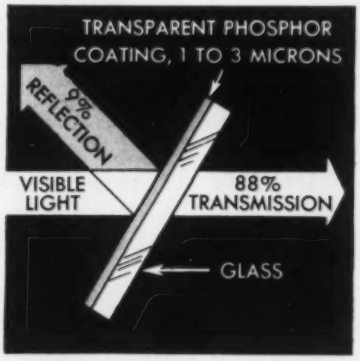


Front-surface mirrors recommended for optical, commercial and scientific uses are among the vacuum-deposited coating products supplied by Liberty Mirror.

These front-surface mirrors give a perfect single reflection. Back-surface mirrors may reflect a second image from the front surface of the glass. The reflective aluminum deposit is coated with hard quartz to increase durability.

Applied to glass, metal or plastic, vacuum-deposited coatings are used in such varied applications as toys, cameras, pin setters, wheel-alignment equipment, aircraft or missiles.

Transparent phosphor coating illuminates with extreme resolution



Liberty Mirror's evaporated coating technique gives this phosphor coating excellent resolution capabilities for use in electronic projection applications. The coating has a light output of 15 foot lamberts or greater, at a power dissipation level of 25 milliwatts with peak output using a screen voltage up to 15 kv.

For assistance in solving application problems, write Liberty Mirror Div., Libbey-Owens-Ford Glass Company, 811 Madison Ave., Toledo 1, Ohio.

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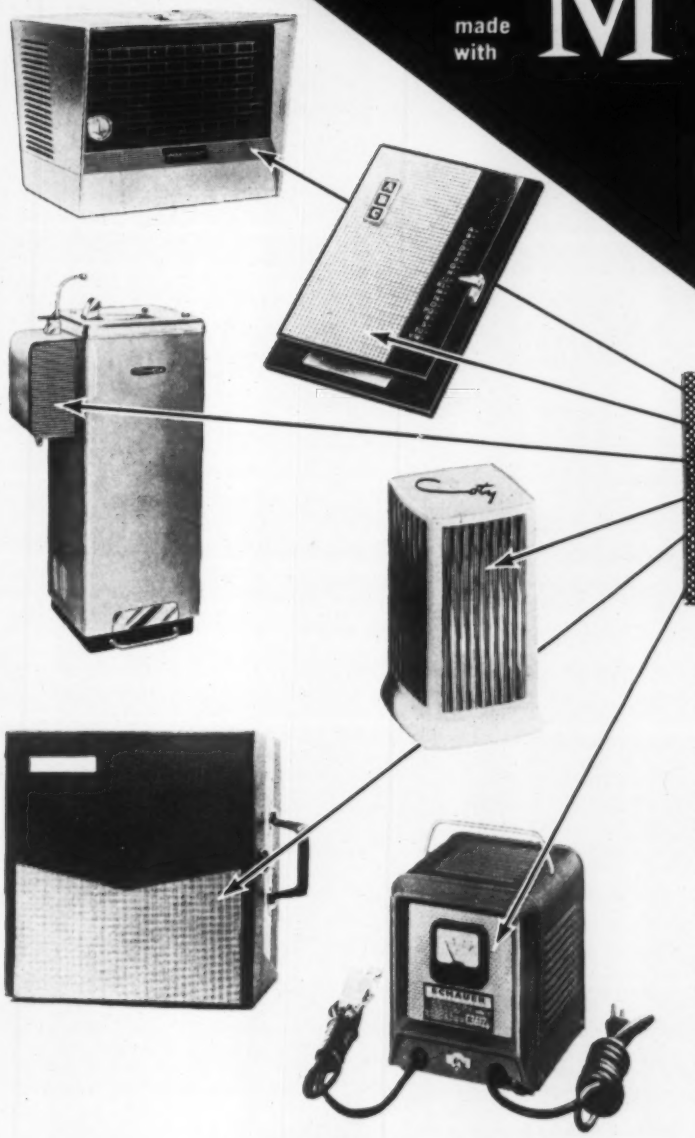

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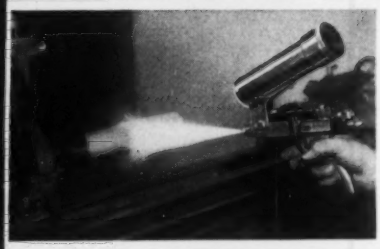

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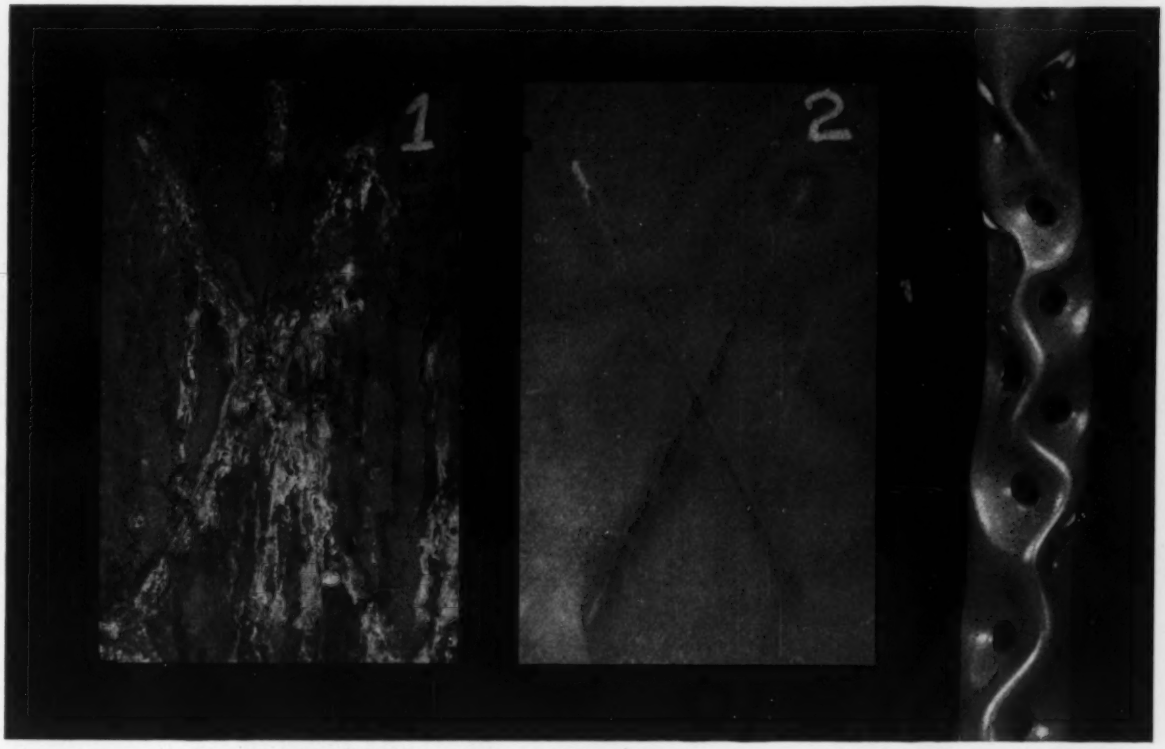

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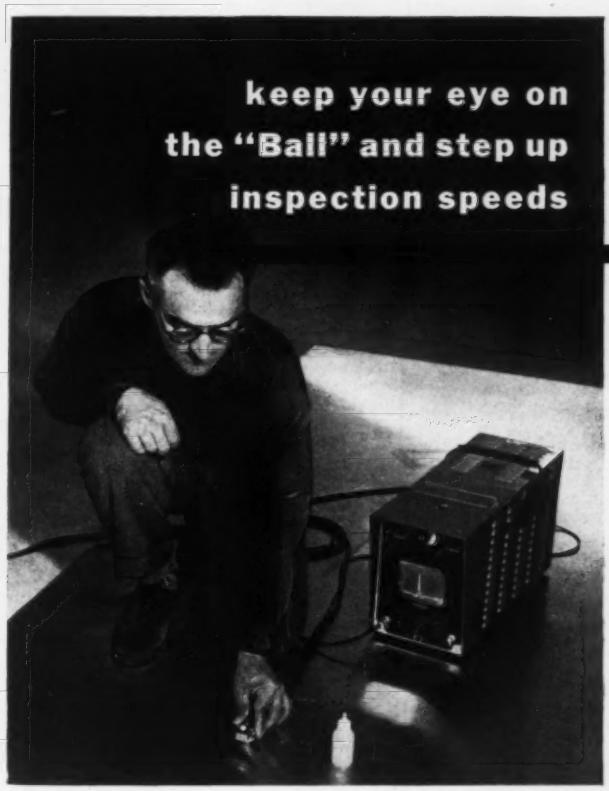

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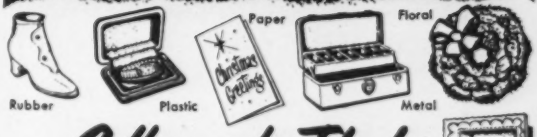

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Molded Rubber Products. Acushnet Process Co., 34 pp, illus. Design data, characteristics and uses of compression and transfer molded synthetic and natural rubber seals, diaphragms, o-rings and other products. **180**

Aluminum Publications. Aluminum Co. of America, 30 pp. Index to available literature on aluminum lists, with brief descriptions, items of interest to engineers, metallurgists, and metal users. Some of the subjects covered are aluminum alloys; design data; castings; forgings; fasteners; powders; wire, rod and strip; and uses of aluminum in the aircraft, appliance, automotive, electrical, processing, and heavy machinery industries. **181**

Ductile Iron Parts. American Cast Iron Pipe Co., Special Products Div., 36 pp, illus. Grades, dimensions, weights, uses and specifications for ductile iron piping, rolls and other parts. **182**

Shaped Steel Wire. Page Steel & Wire Div., American Chain & Cable Co., Inc., 16 pp, illus. Sizes, tempers and finishes of square, rectangular, round, oval, hexagonal and octagonal wire made of low and high carbon steels, iron and stainless steels. **183**

Metal Powders. Metals Disintegrating Co., Div. of American Marietta Co., illus. Description, specifications, properties and uses for all types of metal powders. **184**

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Rubber, Plastics O-Rings. Auburn Mfg. Co., 20 pp, illus. Design data, properties and sizes of o-rings made of natural and synthetic rubber and plastics. **188**

Magnesium Products. Brooks & Perkins, Inc., 8 pp, illus. Shows the fabrication, assembly and finishing of magnesium tail cones for aircraft, teleprinter covers, gun turret enclosures and radar plotting equipment. Information also on other magnesium products. **189**

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Expanded Strip-Tubing. Calumet & Hecla, Inc., Wolverine Tube Div., 8 pp, illus., No. 80. Advantages, alloys used, method of fabrication, sizes, and other data on seamless light-wall tube produced in strip form, rolled up for compact shipment, and then expanded into tubular form. **191**

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Plastics and Rubber Extrusions. Conneaut Rubber & Plastics Co., 4 pp, illus., No. CR-57. Information on compounding and production facilities available for the production of plastics and rubber extrusions. **194**

Plastics Extrusions. Crane Plastics, Inc., 8 pp, illus. Information on services and facilities available for the production of plastics extrusions. Included are a list of extrudable materials and products, and brief descriptions of several custom engineered plastics extrusions. **195**

Reinforced TFE. Dixon Corp., Plastics Div., 2 pp. Electrical, physical, mechanical and chemical properties of reinforced TFE. **196**

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High Alloy Castings. Duraloy Co., 20 pp, illus., No. G-159. Physical properties of corrosion resistant, heat resistant and abrasion resistant high alloys for static, centrifugal and shell molded castings. **200**

Permanent Mold Castings. Eaton Mfg. Co., Foundry Div., 18 pp, illus. Describes permanent mold process for producing gray iron castings. **201**

Aluminum Castings. Exalco Mfg. Co., 4 pp, illus. Information on standard and custom-made aluminum permanent mold castings. **202**

Metallic, Nonmetallic Stampings. Federal Tool & Mfg. Co., 6 pp, illus., No. 301. Design information, tolerances and specifications for stampings made of ferrous and nonferrous metals, and phenolic, nylon and epoxy resins. **203**

Reinforced Plastics. Firmaline Products of Crompton & Knowles, 4 pp, illus. Advantages, properties, typical applications and molding techniques for a line of reinforced plastics premix molding compounds. **204**

Molded Plastics. Plastics Div., General American Transportation Corp., 16 pp, illus. Information on the advantages and characteristics of molded plastics. Included is a description of services and facilities available for compression and injection molding, reinforced plastics molding, extrusion, and vacuum forming. **205**

Aluminum Extrusions. General Extrusions, Inc., 6 pp, illus. Properties, uses, surface finishes, lengths and tolerances of aluminum extrusions. **206**

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Electrical Contact Materials. Gibson Electric Co., 4 pp, illus., No. 601. Properties, available forms and uses of silver, palladium-nickel, silver-graphite and silver-tungsten electrical contact materials. **208**

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Metal Powder Parts. Supermet Div., Globe Industries Inc., 4 pp, illus. Properties, advantages, types of parts, machinability, processes used, and other information on iron powder parts. **210**

Ceramic Parts. Globe-Union, Inc., Centralab Electronics Div., 4 pp, illus., No. 42-874. Reference folder contains 3 useful tables: temperature conversion from Centigrade to Fahrenheit, decimal equivalents of fractions, and mechanical and electrical properties of high alumina and steatite ceramics. Also included is a list of design considerations for ceramic products. **211**

Rubber Parts. Goshen Rubber Co., 8 pp, illus. Describes facilities for

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Design Features of Metal Forms

Form ↓	Choice of Materials	Complexity of Part	Maximum Size	Minimum Size	
Sand Castings	Wide—ferrous and nonferrous metals	Considerable—holes, bosses, locating pads	Great—largest forms made are sand castings	⅛ in. is smallest practicable section	
Shell Mold Castings	Wide—same as above excepting low carbon steels	Moderate—limited by mold removal problem	<60 in. square. Best for smaller parts	1/16-in. sections	
Permanent Mold Castings	Restricted—brass, bronze, aluminum	Limited—restricted by use of rigid molds	Moderate—50 lb is practical limit in aluminum	1-oz. sections as thin as 0.1 in.	
Plaster Mold Castings	Narrow—brass, bronze, aluminum	Considerable—mold destroyed in removal	Moderate—up to 15 lb in most materials	Small—1/32-in. sections possible	
Investment Castings	Wide—includes materials hard to forge or machine	Considerable—very few limitations	Moderate—best for parts under 2 lb	Small—sections down to 0.030 in.	
Die Castings	Narrow—zinc, aluminum, brass, magnesium	Considerable—though costly dies might be required	Large—up to 75 lb in aluminum, 200 lb in zinc	Sections as small as 0.025 in.	
Drop Forgings	Medium—many ferrous, nonferrous alloys	Moderate—limited by die restrictions	Large	Small as fraction of an ounce	
Press Forgings	Medium—best for nonferrous alloys	Limited—but greater than drop forgings	Large—300-400 lb a practical maximum	Smaller than drop forgings	
Upset Forgings	Medium—many ferrous, nonferrous alloys	Limited to cylindrical shapes	Medium—9-in. bar about largest	Moderate—not comparable to casting	
Cold Headed Parts	Narrow—confined to steel, highly ductile alloys	Limited—less flexibility than forgings	Small—7 in. by ½ in. dia usual maximum	Small—⅛-in. dia parts can be made	
Continuous Cast Parts	Narrow—bronze, nickel bronze	Limited—can be complex in cross section only	Moderate—9 in. max dia	Moderate—3/32 in. for sections	
Extrusions	Medium—light metals, steels, copper, titanium, nickel alloys	Limited—can be complex in cross section only	Medium—8 to 21 in. max dia	Small—0.050-in. sections in aluminum and magnesium	
Impact Extrusions	Narrow—aluminum, magnesium, some steel	Limited—must be concentric	Small—6 in. dia in soft alloy, 4 in. in hard	Moderate—¾ in. dia smallest	
Roll Formed Shapes	Narrow—cold rolled steel, some aluminum	Restricted to thin and uniform cross sections	Large	Sections from 0.125 in. up	
Stamped and Press Formed Parts	Wide—all workable metals	Moderate—some design restrictions	Large	Small—sections as thin as 0.003 in. possible	
Metal Powder Parts	Moderate—iron, steels, nickel, brass, nickel alloys, refractory metals	Limited—powders flow poorly, do not transmit pressure	Small—parts less than 4 in. square best	Small—<1/16 in. dia possible	
Spinnings	Wide—many sheet metals	Limited—cylindrical or concentric shapes	Large—up to several feet in dia	Moderate—¼ in. dia in gages less than 0.040 in.	
Screw Machine Parts	Wide—best suited to highly machinable metals	Moderate—limited to rotational shapes	Medium—up to 6 in. long, 2½ in. dia	Small—<1/16 in. dia	
Electroformed Parts	Narrow—iron, copper, nickel, silver	Great—extreme complexity possible	Limited—½-in. sections can be built up	Small—0.005 in. or less	
Tubing	Wide—any ductile metal available in tubular form	Limited by sectional shapes of tubing	Usually 4 to 6 in. o.d.; up to 20 in. possible	Moderate—¼ in. o.d.	
Welded and Brazed Parts	Wide—dissimilar metals can be joined	Great—extremely complex shapes	Unlimited	Moderate	

	Mechanical Properties	Precision, Tolerances	Special Structural Characteristics	Surface Smoothness	Surface Detail	Remarks
	Fair to high depending upon metal cast	±1/16–1/32 in./in., closer at extra cost	Good bearing structure	Poor	Poor	Usually require some machining before use
	Good—little porosity, few gas inclusions	±0.003–0.005 in./in.	High quality for cast metals	Good	Good	Considered best of low cost castings
	Good—high in centrifugal castings	±0.01–0.05 in.	As above	Good	Good	Large quantities allow production economies
	Fair	±0.010–0.005 in.	—	Good	Good	Little finishing required
	Good	±0.005 in./in. common, ±0.002 in./in. possible	High quality for cast metals	Excellent	Excellent	Best for parts too complicated for other casting
	Fair	±0.001 in./in.	Special properties can be obtained through use of inserts	Good	Good	Most economical where applicable
	High	±0.010–0.030 in. without joining	Grain flow provides toughness	Fair	Fair	Used where high strength is required
	High	±0.005 in.	Hot working gives structural advantages	Fair	Fair	Closer tolerances and greater complexity than drop forgings
	High	Medium—compare to press forgings	Grain flow provides toughness	Medium	Medium	Best suited to small parts
	High	±0.010 in. common, ±0.002 in. possible	Tough structure	High	Fair	High production rates
	Good to high depending on alloys	±1/64 in., closer on rounds	High quality for cast metals	Good	Only as part of contour	Provides long section and complex shapes
	Good	±0.005 in. common for nonferrous metals; ±0.125 in. for steels	Grain flow improves properties	Good	Only as part of contour	Sometimes used as blanks for other processes
	High—metal cold worked	±0.001 in. common	Grain flow improves properties	Good	Good	Can eliminate machining
	Good	±0.002 in. common	Cold work improves properties	Good	None	Requires large quantities
	Good to high	Good—to ±0.001 in. common	—	High	Good to excellent	Extremely low cost in quan, otherwise moderate
	Fair to good	Good—±0.001-0.005 in. common	Porosity can be controlled and complex materials formed	Fair	Fair	Can use materials not formable by other processes
	Good	Fair—±0.015-0.060 in. common; better at added cost	Grain flow, cold work improve properties	Good	None	Good for large pieces or short runs
	High	±0.001–0.005 in. possible	—	Excellent	Good	High production rates, low cost
	Fair—lower than wrought	High—±0.002–0.0002 in. common	—	Excellent	Excellent	Best when complexity and accuracy essential
	Good—cold working improves properties	Good—depends on quality of tubing	Grain flow improves properties	Good	None	Good means of reducing costs
	Variable—depends upon components	Medium—not highly precise	Can combine parts with special properties	Depends on components	None	Often needed to meet design requirements

Castings

General

Sand castings. These castings are usually the first type considered. A major advantage is their availability in almost limitless shapes and in extreme complexity. Sand castings can be extremely large, but there is a practical limit to their minimum size. The process is not recommended for thin-section castings.

When moderate quantities of a part are required, sand castings can be relatively inexpensive, despite the hand labor required. Practically any metal can be used, with the exception of the newer metals which react with air while in the molten state. For precision parts, sand castings are usually restricted to the light alloys and certain bronzes.

Shell mold castings. The major advantage of shell mold casting is its ability to produce parts having a high degree of dimensional accuracy and a finish of sufficiently high quality to eliminate most finishing operations.

In many respects, shell casting compares with sand casting, but with the exception that the mold in which the casting is poured is composed of a mixture of sand and resin which has been formed over a metal pattern and then baked. Shells can be made with extremely smooth surfaces, sharp corners and fine detail, all of which can be imparted to the finished castings.

The overall quality of shell mold castings is generally superior to that of sand castings due to absence of moisture and to the porosity of the shells which allows gases to escape. Their primary characteristic, however, is close dimensional tolerances. Often called precision sand casting, this method allows tolerances of ±0.002–0.005 in. per in. to be achieved. Some foundries have been able to hold dimensions even more closely on larger pieces.

The range of materials that can be cast in shell molds is quite wide—almost equal to that of sand casting. There are, however, a few metals and alloys that cause difficulties. For example, low carbon steels are prone to various surface defects; brasses and bronzes with high lead and tin contents are inclined to sweat and cause trouble; and magnesium requires the use of special inhibitors in the shell to prevent difficulties caused by the reaction of magnesium with oxygen and silica sand.

Major disadvantages of shell molding include: necessity for expensive metal patterns and fairly expensive equipment for making and heating the molds; expensive resin binders; inability to reclaim the sand economically; and limitations on size of castings. It is generally felt that for optimum combination of accuracy, economy and quality, castings should be no larger than about 25 lb.

Slush castings. This method is used to produce hollow castings in metal molds without using cores.

Molten metal is poured into the mold which is immediately turned upside down so that the metal remaining liquid can run out. This leaves a thin-walled casting whose thickness depends on the chilling effect of the mold and the time of operation. The casting is removed by opening the halves of the mold.

This method is used only for ornamental objects, statuettes, toys and other novelties. Metals used are lead, zinc and various low melting alloys. Cast parts are generally painted or finished to represent bronze, silver or other more expensive metals.

Continuous castings. Although the continuous casting process is used primarily for the production of aluminum, magnesium, steel and copper alloy bar, billet, ingot and cold rolling slabs, one method—known as the Asarco Process—is used to produce copper alloys in shapes roughly analogous to shapes produced by extrusion.

Primary advantages of all continuous casting processes—which consist essentially of continuously pouring molten metal into a mold, rapidly cooling the metal, and withdrawing it—are uniform cross section, grain structure and composition.

In the Asarco Process, used for phosphorized copper and many standard bronzes, castings can be produced with satisfactory surface finishes as rounds, tubes, squares and special shapes. Some of the parts made from Asarco continuous castings include valve guides, bushings, thrust washers, retainers, gears, brake disks, nozzles, seals, sleeves, lugs and bearings. Special advantages claimed for this process are "lower materials costs, faster production and better products."

Sizes of rods and tubes available range from ½ to 9 in. in dia.

Permanent mold castings. Parts must be of relatively simple design, but some complexity is possible by using sand cores with steel molds (semipermanent molding). Because of the relatively low temperature limit of the mold material, the process is limited to the lower melting alloys. Aluminum alloys are the most commonly cast. Copper-base alloys, magnesium and, more recently, gray iron are also cast in permanent molds.

Permanent mold castings are usually dense and fine-grained, and can be made with better surfaces and closer tolerances than sand castings. Molds may be preheated to the 700-800 F range to achieve high control. Tolerances must be wider than for die castings, shell mold castings and plaster mold castings.

Plaster mold castings. These castings are noted for their fine finishes which reflect the smoothness of the plaster in which they are cast. The insulating quality of the mold causes a slower cooling rate which results in a reduction of tensile strength and

elongation. Although plaster mold castings are used for some high production parts, they are usually considered for small to medium-sized lots. Molding costs are relatively high, but these costs are usually recovered because of the minimum of machining.

Because of the temperature limitations of the mold material, this method is restricted to casting alloys with a melting point below 2000 F. These include aluminum, magnesium, and some of the copper-base alloys, such as yellow brass, silicon bronze, beryllium bronze, aluminum bronze and manganese bronze. Some foundries restrict lead content to 1.5% because of the reactivity of lead with plaster; others claim to have cast 50% lead alloys without difficulty. Alloys containing silicon lend themselves to finer detail with better surface finish. When casting magnesium, special plaster compositions and handling techniques are required, as well as more ample feeding facilities in the mold.

Centrifugal castings. Parts are limited in size and shape, but for large runs there are cost advantages in the elimination of risers or feedheads and of cores in cylindrical shapes. Parts have a dense metal structure with impurities forced back to the center where they can be machined out. Any metal can be cast by this process, and the pressure exerted means that sections can often be thinner than if cast by static methods. A disadvantage is that heat transfer to walls of metal molds and to the center air space must be controlled. For this reason the mold cavity is sprayed with sand or a refractory coating. Limiting dimensions for cylinders are lengths up to 347 in. and diameters from 2 to 50 in. Tolerances are of the same order as in other close tolerance casting methods.

The centrifugal casting method—rotating the mold as the metal solidifies—has three variations: (1) true centrifugal casting—mold is rotated about its horizontal or vertical axis; used for mass production of pipe, large gun barrels and liners, cylinder liners, brake drums and aircraft engine cylinders; (2) semi-centrifugal casting—centrifugal force causes molten metal to flow from a central feeding reservoir into one or more sand molds rotated about their central axis; used primarily for wheels; (3) centrifuging—low rotational speeds are used and the castings need not have axes of rotation but are spaced about a central feed reservoir; used for nonsymmetrical objects such as bearing caps and small brackets.

Investment castings. These parts are formed using a pattern molded in wax, plastic, or frozen mercury. Each pattern type has characteristics that make it more suitable for certain parts. Wax permits the greatest flexibility of design and is the least costly. Plastics permit more rapid production of patterns and also allow a surplus of patterns to be stored for future use. Frozen mercury allows larger sizes to be cast and requires only a thin ceramic shell which, in turn, results in better metal quality. In general, investment cast parts offer dimensional tolerances superior to those of other castings, can be made in shapes too complex for metal powder parts, and can be made of metals with melting points too high for die casting. Mechanical properties are generally high.

Of the seven types of close tolerance castings (i.e., excluding sand castings), investment castings are matched only by shell moldings and centrifugal castings in the range of castable alloys available. These alloys include high melting ferrous alloys, copper alloys, special high temperature nonferrous alloys, and all castable aluminum and magnesium alloys.

continued on next page

MACHINE FINISH ALLOWANCES

Metal ↓	Pattern Size, in.	Bore, in.	Finish, in.
Cast Iron	Up to 12	1/8	3/32
	13 to 24	3/16	1/8
	25 to 42	1/4	3/16
	43 to 60	5/16	1/4
	61 to 80	3/8	5/16
	81 to 120	7/16	3/8
	Over 120	g	g
Malleable Iron[a, b, c, d]	Up to 6	1/16	1/16
	6 to 9	3/32	1/16
	9 to 12	3/32	3/32
	12 to 24	3/32	1/8
	24 to 35	3/16	3/16
	Over 36	g	g
Steel[e]	Up to 12	3/16	1/8
	13 to 24	1/4	3/16
	25 to 42	5/16	5/16
	43 to 60	3/8	3/8
	61 to 80	1/2	7/16
	81 to 120	5/8	1/2
	Over 120	g	g
Brass, Bronze, Aluminum[f]	Up to 12	3/32	1/16
	13 to 24	3/16	1/8
	25 to 36	7/16	5/32
	Over 36	g	g

[a] When castings are constructed so that they warp more than the average amount, the allowances given should be increased.
[b] Disk grinding—only sufficient finish required to take care of draft and possible warpage.
[c] Coin pressing—practically no finish allowance required.
[d] For small parts, an allowance of 1/32-1/16 in. is satisfactory. Larger parts require a slightly greater allowance.
[e] Allowance ranges from 1/8 to 1 in. Values given for finish are normal for ordinary finishes on the drag side. For finished surfaces on the cope side, it is often necessary to double the allowance.
[f] For small or medium-sized nonferrous castings, 1/8 in. is a customary allowance, with correspondingly larger allowances on larger castings.
[g] Special instructions.

Castings

Though the same general degree of accuracy is obtainable with all alloys, it is easier to obtain with the nonferrous alloys because of their higher fluidity and lower melting points.

Die castings. Only nonferrous alloys are suitable for die castings. The range of these alloys is adequate for most needs but more limited than for sand castings. Alloys used, in order of tonnage, are: zinc, aluminum, copper, magnesium, lead and tin. They can be grouped in low and high melting classes according to melting point:

Low melting alloys	
Zinc	727 F
Lead	484 F
Tin	417 F
High melting alloys	
Aluminum	1115 F
Magnesium	1110 F
Copper	1600 F

The high melting group are usually cast in cold chamber or air injection machines; the low melting alloys in plunger machines. Of all casting processes, die casting is by far the best suited to high production of quality parts. As in permanent mold casting, an advantage is derived from the high thermal conductivity of the steel used in the die. The resultant chilling effect promotes fine grained metallurgical structure. Though die castings are subject to varying degrees of porosity, proper engineering of the casting and die may confine it to noncritical areas.

Design Factors

Draft allowances. Draft allowance is normally at least ½ in. per ft., although it often ranges from ¼ to ⅜ in. per ft. It is seldom less than 1 deg and ⅛ in. per ft. In sand and plaster mold casting, the mold is destroyed; therefore the draft required is only necessary to remove the pattern. Investment casting requires no draft, though ½ to 1 deg can be specified for single parting, noncored dies. Frozen mercury, wax and plastics patterns require no draft, but ½ deg is used with Kirksite dies.

Permanent mold—A minimum of 2 deg on each side is usually provided, though the range is 0 to 3 deg. In recesses, 2 deg on each side is a minimum with 5 deg desirable. The following figures (in. per in. of depth on one side) are fairly standard: magnesium—0.015, aluminum—0.015, bronze—0.020.

Shell mold—Draft angles are not as critical as for permanent mold castings. From ¼ to ½ deg is

DIMENSIONAL TOLERANCES (In.)*

Sand Castings	
Gray Iron	1/32–1/16
Malleable Iron	3/32
Steel	3/32
Aluminum Alloys	5/64
Magnesium Alloys	11/64
Brass	3/32
Bronze	1/8
(Zinc, tin, lead not cast)	
Shell Mold Castings	
Ferrous	0.001–0.003 in./in. possible. Commercially 0.010 to 0.015 are held on dimensions within mold half. Across parting line: 0.020–0.030
Magnesium, Others	Same as ferrous
(Zinc, tin, lead not cast)	
Permanent Mold Castings	
Aluminum	0.015 for first inch; then 0.002 in./in. Common total: 0.010–0.050
Magnesium, Gray Iron, Others	Same as aluminum or slightly wider
(Steel, tin not cast)	
Plaster Mold Castings	
Brass, Bronze	0.005 for first inch; then 0.001 in./in. Common total: 0.005 to 0.010
Aluminum, Others	Same as brass and bronze
(Ferrous, zinc, tin, lead, copper not cast)	
Investment Castings	
Copper	0.002–0.005 in./in.
Stainless Steel	0.004–0.008 in./in.
Others	0.003–0.006 in./in.
(Iron, some steels, zinc, tin, lead not cast)	
Die Castings	
Zinc	0.0025 for less than 1 in. 0.001 in./in. for dimensions greater than 1 in.
Aluminum, Magnesium	0.003 for less than 1 in. 0.001–0.002 in./in. for dimensions greater than 1 in.
Others	0.005 for less than 1 in. 0.003 in./in. for dimensions greater than 1 in.
(Ferrous not cast)	

*Tolerances are for usual commercial practice, stated for guidance only. In most cases closer tolerances can be held at increased cost. Tolerances are over-all unless stated as in. per in. All values are ± tolerances.

usually sufficient for shell mold castings.

Die—In general, a minimum of 2 deg per side is usually provided. The following draft tolerances (in.) are usually provided:

Magnesium	0.010[a]
Aluminum	0.010-0.015
Zinc	0.005-0.007
Brass, bronze	0.015-0.020
Tin, lead	0.015

[a] In. per in. of depth, one side.

Shrinkage allowances. The following allowances (in. per ft) are usually provided:

Cast iron	1/8
Malleable iron	1/8
Steel	1/4
Aluminum	5/32
Brass	3/16

Design Rules

1. Stress concentration is always a vital consideration. A larger amount of metal will have greater shrinkage and put an adjoining thin section under tension which may result in cracking. The design should incorporate fillets when there is a change of section thickness or to avoid sharp, interior corners. In addition to lowering stress concentration, fillets help achieve even cooling and shrinkage.

2. Continuous, intersecting ribs may cause trouble. Staggering the ribs will help prevent the build-up of high stresses.

3. Avoid large, flat areas with little or no support.

4. The parting line, particularly in die castings, is preferably located at the corner of the casting. Lines of demarcation remaining after flash removal will not be nearly as visible.

MINIMUM SECTION THICKNESS (In.)[a]

Sand Castings	
Gray Iron[a]	1/8–3/16
White Iron	1/8–3/16
Malleable Iron	1/8–3/16
Steel	3/16–1/4
Aluminum	1/8–3/16
Magnesium	3/16–1/4
Brass, Bronze	3/32–1/8
Shell Mold Castings[b]	
Ferrous	1/16–1/8
Magnesium, Others	1/16–1/8
Permanent Mold Castings	
Aluminum	
< 3 In.	3/32–1/8
3 to 6 In.	5/32
>6 In.	3/16
Gray Iron, Others	
<3 In.	3/32–1/8
3 to 6 In.	5/32
>6 In.	3/16
Plaster Mold Castings	
Brass, Bronze	
2 Sq In.	0.040
4 to 6 Sq In.	0.063
<30 Sq In.	0.093
Aluminum, Others	
2 Sq In.	0.040
4 to 6 Sq In.	0.063
<30 Sq In.	0.093
Investment Castings[b]	
Copper	0.030
Stainless Steel	0.050
Others	0.030
Die Castings	
Zinc	
Small	0.020–0.030
Large	0.050
Aluminum	0.035
Magnesium	0.050
Aluminum Alloy	
Small	0.045–0.055
Large	0.080
Magnesium Alloy	
Small	0.050–0.060
Large	0.080
Copper	
Small	0.06
Large	0.10
Brass, Bronze	0.050
Tin	
Small	0.030
Large	0.060
Lead	
Small	0.040
Large	0.070

[a] Usual minimum for various classes of gray iron is: class 20, 1/8; class 25, 1/8; class 30, 1/4; class 35, 3/16; class 40, 1/2; class 50, 1/2; class 60, 3/4.
[b] Avoid section differences where max : min ratio is more than 5 : 1.

Extrusions

General

Extrusions are used extensively as a means of making small parts of uniform cross section that might otherwise be made only through extensive machining. Long pieces of the desired cross section are extruded, then cut to desired lengths and subjected to any further operations that may be required.

Advantages. Extruded shapes are not considered to be highly precise as far as dimensional tolerances are concerned, but they do have the advantage of permitting the metal to be placed where it is most needed to attain desired strength and design characteristics. Relatively complex shapes can be extruded. Sharp corners and reentrant angles are readily obtainable. When precision is a requirement, final dimensions are achieved through machining. Extruding is sometimes used to make blanks for other processes, e.g., forging.

Limitations. Sizes are limited because of the excessive size of the presses required to extrude large sections, and because large shapes are likely to bend and distort excessively under their own weight and require expensive straightening operations. Any openings must be in the direction of the extruding action and uniform throughout the entire length of the extrusion.

Materials. Although in the past most extruded shapes have been made from aluminum, magnesium and copper alloys, the process has recently been expanded to include many types of steels. Steels and other high melting alloys are easy to extrude, but they are hard on die materials and require lubricants with special qualities. Titanium, lead, tin and zinc alloys are also extruded. For best results the ratio of billet size to finished extrusion should be large. When large ratios are used, the resulting extrusions are dense, homogeneous and free of porosity, and the metal properties compare favorably with those attained in forging. Ratios usually range from 20:1 to 40:1.

Speed of output. Rate of output of extruded shapes can affect cost, particularly if large quantities are required. Speeds range from 1½ to 700 fpm, depending on the basic material, the particular alloy and the shape being extruded. Magnesium is extruded at speeds of 4 to 100 fpm, aluminum somewhat faster, and copper alloys a little slower. Highest speeds are attained with nickel alloys and steels.

Applications. Conditions under which extruded shapes might be chosen are:

1. When a more efficient disposal of metal is desirable than is obtainable with rolled shapes or other metal forms.
2. Where several parts are now joined to provide a small assembly.
3. Where shapes are required that could not be obtained without difficult machining.
4. Where short pieces of an extrusion could replace small castings or forgings.

Design Factors

Tolerances. Tolerances on extruded metal parts are held on such factors as straightness, flatness, twist, section thickness, angles, contours, and corner and fillet radii.

Flatness—On a 6-in. width, tolerance would be ±0.024 in., or about 0.004 in. per in. of width.

Straightness—On a 5-ft length, a 1/16-in. deviation from a straight line is normal. This deviation increases to ⅜ in. at 30 ft.

Cross section—Typical are tolerances ranging from ±0.006 in. on thicknesses of less than 0.125 in. up to ±0.080 in. on thicknesses or widths of 14-15 in.

Cut ends—Permissible deviation from the square is 1 deg.

Curved surfaces—Allowable deviation from a specified contour is 0.005 in. or 0.004 in. per in. of chord length, whichever is greater. This tolerance does not apply to an arc of more than 90 deg.

Section thickness. Thickness of sections usually ranges from 0.050 in. up to several inches. Ratios of thickness to width vary with materials used and are standardized for aluminum and magnesium extrusions. Aluminum alloys, such as 3003 and 6063 have a ratio of 8 in. wide to 3/32 in. thick; for 2014, it is 8 in. wide to ⅛ in. thick.

Design Rules

1. Extruded shapes are usually restricted to those that can be contained within a circumscribing 21-in. circle. Within this range, parts can be made as solid, hollow or semihollow shapes; T, L or V sections; rectangles; and complex shapes.
2. Avoid extremely thin sections within a large circumscribing area.
3. Avoid semihollow sections with unbalanced die tongues.
4. Avoid sections with extreme thickness variation.
5. Avoid hollow shapes having unsymmetrical voids or inadequate thickness between voids.

Stepped Extrusions

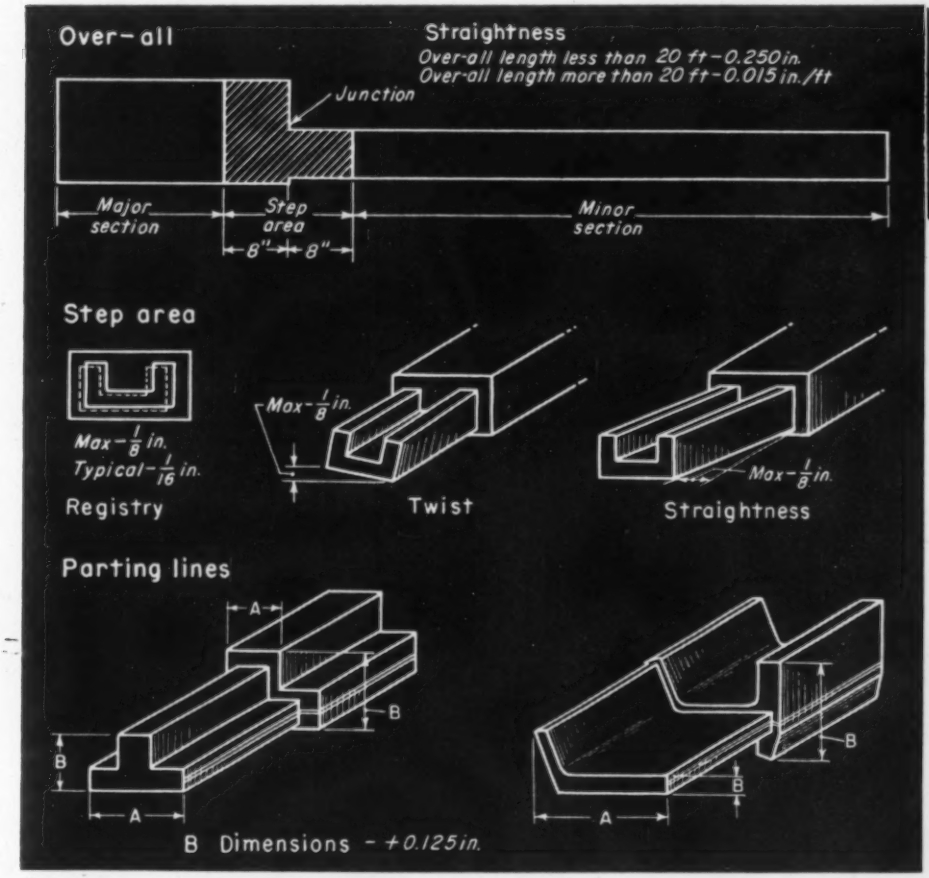
Stepped extrusions are commonly produced by utilizing two sets of extrusion dies.

In designing a stepped extrusion it is important to use dimensional tolerances that are realistic, yet avoid an excess of stock. Stepped extrusion tolerances have not been standardized, but those given in the accompanying sketches are typical. Straightness tolerances differ from those for normal extrusions. In addition, special tolerances apply to the step area and across the parting line when split dies are used.

Because of the inherent instability of split dies, cross section tolerances of stepped extrusions are usually greater than for normal extrusions. In locating parting lines, it is important to consider not only tolerances but also the ability to remove tools from the section. It is sometimes necessary to provide slight draft angles on extended elements.

Although the major and minor sections may frequently have a common plane, this is not a requirement of the process. In all cases, however, the major section must completely enclose the minor section. It is generally necessary to provide machining stock on all surfaces to obtain the required dimensional accuracy and surface finish.

Straightness of the over-all part is measured by deviation from a reference line, the junction or step area (8 in. on either side of the step) being excluded. Straightness of the minor or major portion of the extrusion is determined individually. Because of the difference in flow conditions in extruding the major and minor sections, the junction area usually presents the greatest straightening problems. Minor and major portions are usually furnished to standard extrusion straightness tolerances.



Impact Extrusions

General

Parts made by impact extruding cannot be very large or very small. They must be concentric in design, but can be provided with lugs, flutes and similar projections. Mechanical properties of impact extruded parts are usually high because of the tremendous amount of cold work involved in the process; this is particularly true of carbon steels.

Often a concentric impact extrusion is sectioned after forming to make two or more parts which could not otherwise meet the design requirements of impact extrusion. Examples are semicircular and U-shaped pieces.

Comparisons. Both impact extrusion and deep drawing use a combination of punch and die to form a hollow shell from a cold blank, and for some parts equivalent speeds are used. The difference lies in the manner in which deformation occurs. In impact extrusion the metal is forced through an orifice between punch and die under compressive stresses; in deep drawing the metal is pulled into the die by the punch and stressed in tension.

Both impact extrusion and ordinary extrusion force metal through a die under compressive stresses. However, the metal is generally cold worked in impact extrusion and hot worked in ordinary extrusion. In addition, impact extrusion produces a single component that may or may not require further operations, whereas ordinary extrusion generally produces a continuous cross section such as a rod, tube or structural shape.

An impact extruded part can be considered as a modified forging in which the flash forms the side walls. The part has a base that, in backward extrusion at least, is a forging, and side walls that are extrusions.

Advantages.

1. High speed production is possible.
2. Unit cost of mass produced parts is low.
3. Materials saving and excellent metal recovery are achieved.
4. Process requires few operations. Ribs, fins, holes, etc., are formed during extrusion.
5. Parts have dimensional uniformity with close diametrical tolerances.
6. Tooling is relatively cheap.
7. Surface finishes on the order of 20 to 70 microinches are obtainable.
8. Bottom thicknesses are independent of wall thicknesses.
9. Parts can be made with zero draft angles and sharp corner radii.
10. Parts have excellent properties; for example, cold formed low or medium carbon steel parts have mechanical properties equivalent to those of heat treated carbon and low alloy steels.

Limitations.

1. Relatively few alloys can be processed commercially at present.
2. Shapes that can be produced are limited.
3. Length-to-diameter ratio is restricted.
4. Maximum size of part is limited by press capacity.
5. Comparatively high equipment costs limit applications to relatively high production runs.

COMMERCIAL SIZE RANGES FOR ALUMINUM IMPACT EXTRUSIONS

Material	Wall Thickness, in.		Diameter, in.	
	Max	Min	Max	Min
1070 (collapsible tubes)...	0.010	0.0035	2½	⅜
1100, 3003.....	½*	0.010	6	¾
Medium Strength Alloys..	½*	0.040	5	¾
High Strength Alloys.....	½*	0.062	4	¾

*Some authorities state that the maximum wall thickness is "not known."

Design Factors

Sizes. Part sizes and dimensional tolerances vary considerably, depending upon the metal. Some typical figures: in aluminum, wall thickness ranges from a maximum of ½ in. down to 0.010 in. in the soft alloys or 0.062 in. in the stronger alloys. Diameters of parts can be as great as 6 in. in the soft alloys and 4 in. in the hard alloys, and as small as ¾ in. Larger parts would require extremely high pressures, and smaller parts would involve excessive tool damage.

Tolerances. Typical commercial dimensional tolerances for aluminum are as follows. On walls as thin as 0.10 in., the tolerance can be held to 0.010 in. Over 0.15 in., the tolerance must be increased to 0.020 in. Diameters can be held to 0.010 in., but lengths are not usually guaranteed any closer than 3/16 in.

Materials. By far the most commonly used material for mechanical parts is aluminum and its alloys. More than a dozen different alloys are used, depending upon the end service requirements, but from the standpoint of extruding 1100 alloy is best.

In steels, best results are obtained with those containing up to 1.2% carbon, although several alloy steels are impact extruded regularly. Steel parts must be somewhat smaller and have greater wall thicknesses than similar parts in aluminum.

Magnesium slugs are heated to 500 to 700 F for impact extruding. Several different alloys can be used, but best results are obtained with alloy AZ31B.

Several other metals are impact extruded to a lesser degree. They include lead, tin, copper, zinc and zirconium.

Fabricated Sheet Metal Parts

Stampings and Press Formed Parts

General. Blanking, piercing, drawing, bending, ironing and coining are all done on hydraulic or mechanical presses, or on drop hammers. The folding up, and sometimes the piercing, of long shapes is done on press brakes. Wrap-around operations on small parts are done on multislide machines. Large quantities of drawn parts are made in eyelet or transfer presses with multiple stations.

Stampings which do not require deep draws and which are less than 6 in. in dia and 0.109 in. thick can be made from coil stock by using progressive dies which combine several operations at each stroke. Such costly dies are rarely justified for runs of less than 30,000 pieces. Sometimes duplicates are made side by side.

Advantages and limitations. Parts can be fairly complex in shape, but the extreme-low-cost advantages disappear as increasing complexity adds to the number of operations required. Because of the many variables in stamping design and stamping equipment, the extent of the advantages is greatly dependent on the knowledge and skill of the die designer. Finishes are good, and the parts are generally uniform and nonporous. Limitations include cost of tools, the roughness of sheared edges, and the difficulty inherent in substantially changing original stock thickness.

Materials. Nearly any metal that can be rolled can be used for stampings. Formed and drawn parts are usually made of soft temper materials, but parts can be heat treated after forming. Commonly used: carbon steels, particularly low carbon steels; copper; brass; bronze; aluminum; magnesium alloys; zinc; titanium; nickel alloys; stainless steels; and some alloy steels. A substantial variety of finishes are applied.

Dimensional tolerances. Stampings may be as thin as 0.003 in., or as heavy as ⅝ in., and may vary in size from tiny shapes to freight car ends. Dimensional tolerances vary with the thickness of the material and the size of the part. Tolerances of ±0.001 in. are available on dimensions up to 2 in., tolerances on the order of ±0.003 in. on dimensions up to 6 in. Heavy material calls for more generous tolerances. It is a general rule that when unnecessarily close tolerances are called for, more expensive tooling, higher costs of tool repair, and sometimes extra operations are required.

Design rules. In general, the following design rules apply to all stamping operations:

1. Material can frequently be strengthened by the addition of flanges, beads, corrugations or ribs.

2. Ribs and bosses should be at least four times as wide as deep, so the metal will stretch.

3. Hole edges may be extruded for greater thread length, etc. The depth of such extrusions without gathering operations should not exceed 15 to 20% of hole diameter.

4. Coining can force metal to flow and thus produce locating projections and grooves. This type of operation is particularly applicable to softer materials and smaller parts.

COMPARATIVE FORMABILITY OF METALS[a]

Metal	Alloy	Rating
Aluminum	1100-O	100
	3003-O	95
Magnesium (hot formed)		95[b]
Aluminum	6061-O	92
	5052-O	80
	7075-O	75
	2024-O	75
	2014-O	75
Deep Drawing Steel	1008	75
Zinc		75
Soft Copper		75[b]
Commercial Steel	1010	70
Soft Brass		70
Aluminum (as quenched)	7075-W	60
	2024-W	60
	2014-W	60
Aluminum	1100-¼H	50
Stainless Steel	Type 302	49
	Type 304	46
Aluminum	3003-¼H	45
Stainless Steel	Type 321	43
Aluminum	5052-¼H	40[b]
	1100-½H	40[b]
Titanium		40
Stainless Steel	Type 347	40
Aluminum	3003-½H	35[b]
	5052-½H	30[b]

[a]Based on rating of 100 for 1100-O aluminum. [b]Tentative.

PENETRATION OF PUNCH THROUGH METAL IN BLANKING OR PIERCING OPERATIONS

Metal	Annealed		Partially Cold Worked	
	Resistance to Shearing, psi	Reduction or Penetration, %	Resistance to Shearing, psi	Reduction or Penetration, %
Lead	3,500	50	—[a]	—[a]
Tin	5,000	40	—[a]	—[a]
Aluminum	8,000	60	13,000	30
Zinc	14,000	50	19,000	25
Copper	22,000	55	28,000	30
Brass	32,000	50	52,000	20
Bronze (90–10)	—	—	40,000	30
Tobin Bronze	36,000	25	42,000	17
Steel				
0.10% C	35,000	50	43,000	38
0.20% C	44,000	40	55,000	28
0.30% C	52,000	33	67,000	22
0.40% C	62,000	27	78,000	17
0.60% C	80,000	20	102,000	9
0.80% C	97,000	15	127,000	5
1.00% C	115,000	10	150,000	2
Silicon Steel	65,000	30	—	—
Nickel	35,000	55	—	—

[a]Anneals at room temperature.

continued on next page

Fabricated Sheet Metal Parts

MINIMUM BEND RADII FOR ALUMINUM SHEET*

Gage, in. ↓	7075-O, 7075-W[b]	7075-T6	2024-O, 2024-W,[c] 2014-O	2014-T3	2024-T3, 2014-T6	6061-O
0.020	1/32	3/32	1/64	1/16	1/16	0
0.025	1/32	1/8	1/64	1/16	3/32	0
0.032	1/16	5/32	1/64	1/16	3/32	0
0.040	1/16	3/16	1/32	3/32	1/8	0
0.051	3/32	1/4	1/16	1/8	3/16	0
0.064	1/8	5/16	1/16	5/32	7/32	0
0.081	5/32	3/8	3/32	7/32	9/32	0
0.091	3/16	1/2	3/32	1/4	11/32	0
0.102	3/16	5/8	3/32	5/16	7/16	0
0.125	7/32	3/4	1/8	3/8	1/2	1/16
0.156	3/8	1	5/32	7/16	5/8	1/8
0.187	1/2	1 1/4	3/16	1/2	3/4	3/16

Gage, in. ↓	6061-T4	6061-T6	5052-O	5052-H32 1/4 Hard	5052-H34 1/2 Hard	5052-H38 3/4 Hard
0.020	1/32	1/32	0	0	0	1/32
0.025	1/32	1/32	0	0	0	1/32
0.032	1/32	1/32	0	0	0	1/32
0.040	1/32	1/32	0	0	0	1/16
0.051	1/16	1/16	0	0	1/32	1/16
0.064	1/16	3/32	0	0	1/16	3/32
0.081	3/32	1/8	0	1/32	1/16	1/8
0.091	1/8	5/32	0	1/16	3/32	1/8
0.102	1/8	3/16	0	3/32	1/8	3/16
0.125	3/16	1/4	0	1/8	1/8	1/4
0.156	5/16	5/16	0	5/32	3/16	1/2
0.187	3/8	9/16	0	3/16	9/32	9/16

Gage, in. ↓	5052-H38 Hard	1100-H12 1/4 Hard	1100-H14 1/2 Hard	1100-H16 3/4 Hard	1100-H18 Hard
0.020	1/32	0	0	0	1/32
0.025	1/32	0	0	0	1/32
0.032	1/16	0	0	0	1/32
0.040	1/16	0	0	0	1/16
0.051	3/32	0	0	1/32	1/16
0.064	1/8	0	0	1/16	3/32
0.081	3/16	1/32	1/32	1/16	1/8
0.091	1/4	1/16	1/16	3/32	1/8
0.102	5/16	3/32	3/32	1/8	3/16
0.125	3/8	1/8	1/8	1/8	1/4
0.156	5/8	5/32	5/32	3/16	1/2
0.187	3/4	3/16	3/16	9/32	9/16

*Minimum allowable radii for bending aluminum alloy sheet depend on thickness, temper and composition. Values given in the table are for 90-deg bends and should be increased for bends greater than 90 deg.
[b]Freshly quenched and formed within 2 hr max, or 24 hr max if iceboxed at 32 F.
[c]Freshly quenched and formed within ½ hr max, or 24 hr max if iceboxed at 32 F.

MINIMUM BEND RADII FOR MAGNESIUM ALLOY SHEET*

Alloy ↓	Forming Temperature, F				
	70	300	400	500	600
M1					
Annealed (M1a)	5T	4T	3T	2T	1T
Cold Worked (M1h)	11T	8½T	6½T	4½T	—
AZ31					
Annealed (AZ31Xa)	3½T	2T	1½T	1T	—
Cold Worked (AZ31Xh)	7½T	3T			
AZ51X					
Annealed (AZ51Xa)	6T	4½T	3½T	2½T	2T
Cold Worked (AZ51Xh)	9T	6½T	4½T		

Experimental values, where T = metal thickness.

MINIMUM BEND RADII FOR AUSTENITIC STAINLESS STEELS*

Annealed	½T to 1T
¼ Hard	1T to 2½T
½ Hard	2½T to 4T
¾ Hard	3T to 5T
Full Hard	4T to 6T

*Where T = metal thickness.

5. Unless the print calls for parts to be washed, deburred, flat within a given tolerance, or specially handled to reduce any marks, stampers make extra charges for such operations.

Pierced parts. The following design rules should generally be observed:

1. The diameter of a hole is measured by its smallest dimension (the edges of a pierced hole are not straight).

2. Hole diameters should be more than two-thirds of metal thickness (larger in hard materials), and never less than 0.030 in.

3. Distance between hole edges, or hole edge and outside periphery, should be greater than metal thickness. For combined operations, a minimum of 3/32 in. is desirable for the die to stand up.

4. If holes are dimensioned from the edges of parts, they may be pierced in the flat. If they are closely dimensioned from bends, secondary operations are necessary.

5. Holes near a bending edge should be a distance of 1½ times metal thickness, plus bend radius, from formed angle. Long slots should be a distance of four or five times the metal thickness from a formed angle. Sometimes such holes are pierced after form-

BEND ALLOWANCES IN STEEL SHEET[a]

Inside Bend Rad., in. ↓	Metal Thickness, in.								
	.022	.028	.035	.049	.065	.095	.120	.187	.250
.032	.00072	.00076	.00082	.00093	.00105	.00129	.00148	.00200	—
.0625	.00126	.00131	.00136	.00147	.00160	.00183	.00203	.00255	—
.093	.00180	.00185	.00191	.00202	.00212	.00238	.00257	.00309	—
.125	.00235	.00240	.00245	.00256	.00269	.00292	.00311	.00364	—
.156	.00289	.00294	.00300	.00311	.00323	.00346	.00366	.00418	—
.1875	.00344	.00349	.00354	.00365	.00378	.00410	.00420	.00473	—
.218	.00398	.00403	.00409	.00419	.00432	.00455	.00475	.00527	—
.250	.00453	.00458	.00463	.00474	.00487	.00510	.00529	.00582	—
.281	.00507	.00512	.00517	.00528	.00541	.00564	.00584	.00636	—
.3125	.00562	.00567	.00572	.00583	.00596	.00619	.00638	.00691	—
.343	.00616	.00620	.00626	.00637	.00650	.00673	.00693	.00745	—
.375	.00671	.00675	.00681	.00692	.00705	.00728	.00747	.00800	.00849
.406	.00725	.00730	.00735	.00746	.00759	.00782	.00802	.00854	.00903
.4375	.00780	.00784	.00790	.00801	.00813	.00837	.00856	.00908	.00958
.468	.00834	.00839	.00844	.00855	.00868	.00891	.00911	.00963	.01012
.500	.00889	.00893	.00899	.00910	.00922	.00945	.00965	.01017	.01067
.531	.00943	.00948	.00953	.00964	.00977	.01000	.01019	.01072	.01123
.5625	.00998	.01002	.01008	.01019	.01031	.01055	.01074	.01126	.01175
.593	.01052	.01055	.01061	.01072	.01084	.01108	.01127	.01179	.01230
.625	.01106	.01111	.01117	.01128	.01140	.01161	.01183	.01235	.01284
.656	.01161	.01166	.01171	.01182	.01194	.01218	.01237	.01289	.01339

[a]Allowance for 1 deg of bend; multiply value in table by number of degrees in bend.

BEND ALLOWANCES IN ALUMINUM ALLOY SHEET[a]

Inside Bend Rad., in. ↓	Metal Thickness, in.								
	.020	.025	.032	.040	.051	.064	.081	.091	.128
.032	.00070	.00074	.00079	—	—	—	—	—	—
.0625	.00125	.00129	.00135	.00140	.00149	.00159	—	—	—
.093	.00179	.00183	.00188	.00195	.00203	.00213	.00226	.00234	—
.125	.00234	.00238	.00243	.00249	.00258	.00268	.00281	.00289	.00317
.156	.00288	.00292	.00297	.00304	.00312	.00322	.00335	.00343	.00372
.1875	.00342	.00347	.00352	.00358	.00367	.00377	.00390	.00398	.00449
.218	.00397	.00401	.00406	.00412	.00421	.00431	.00444	.00452	.00481
.250	.00451	.00455	.00461	.00467	.00476	.00486	.00499	.00507	.00535
.281	.00506	.00510	.00515	.00521	.00530	.00540	.00553	.00561	.00590
.3125	.00560	.00564	.00570	.00576	.00584	.00595	.00608	.00616	.00644
.343	.00615	.00619	.00624	.00630	.00639	.00649	.00662	.00670	.00699
.375	.00669	.00673	.00679	.00685	.00693	.00704	.00717	.00725	.00753
.406	.00724	.00728	.00733	.00739	.00748	.00758	.00771	.00779	.00808
.4375	.00778	.00782	.00787	.00794	.00802	.00812	.00826	.00834	.00862
.468	.00833	.00837	.00842	.00848	.00857	.00867	.00880	.00888	.00917
.500	.00877	.00891	.00896	.00903	.00911	.00921	.00935	.00943	.00971
.531	.00942	.00946	.00951	.00957	.00966	.00976	.00989	.00997	.01051
.5625	.00996	.01000	.01005	.01012	.01020	.01030	.01043	.01051	.01080
.593	.01051	.01055	.01058	.01065	.01073	.01083	.01098	.01105	.01133
.625	.01105	.01109	.01114	.01121	.01129	.01139	.01152	.01160	.01189
.656	.01160	.01164	.01170	.01175	.01183	.01193	.01207	.01214	.01245

[a]Allowance for 1 deg of bend; multiply value in table by number of degrees in bend

continued on next page

Fabricated Sheet Metal Parts

DIMENSIONAL TOLERANCES FOR DRAWN PARTS (In.)

Thickness, in.[a] ↓	Up to 2 In. Dia	Up to 6 In. Dia
1/32	±0.005	±0.008
1/16	±0.006	±0.010
3/32	±0.008	±0.012
1/8	±0.010	±0.015
1/4	±0.015	±0.020

[a] Gage thickness of round shell to be drawn to height of 1/2 to 3/4 shell dia. Tolerances on irregular shapes are 20% higher.

RECOMMENDED MAXIMUM REDUCTIONS IN DRAWING (%)[a]

Low Carbon Steel	45
Austenitic Stainless Steels	50
Copper	45
High Brasses (70–30, 63–37)	50
Tin Bronze	50
Aluminum (annealed, 1/4 hard)	45
Aluminum Alloys	
Annealed, 5052 (1/4 hard)	45
Heat Treatable, As Quenched	40
Zinc	40

[a] Ratio of inside cup diameter to blank diameter.

PERMISSIBLE STRETCH IN STRETCH FORMING THIN-WALLED SECTIONS (%)

Aluminum Alloys	
2024-O, 7075-O	10
2024 (-O, -T or as quenched)	6[a]
6061-O, 5052-O	25
Austenitic Stainless Steels (type 301)	
Annealed	20[b]
1/4 Hard	15–20
1/2 Hard	5–10
3/4 and Full Hard	2

[a] Up to 10% in the web.
[b] Up to 30% for symmetrical and rigid sections.

ing, in which case a minimum of 3/32 in. for die wall is required.

Formed parts. The following design rules may be applied to formed parts:

1. The height of a formed projection should be greater than 1½ times material thickness, and preferably over ⅛ in. min.

2. Bends in metals which are not soft should be made at right angles to the grain or rolling direction of the metal.

3. Because of springback, which varies with materials and tempers, angular tolerances of at least one deg are necessary (more on short projections).

4. Minimum radii obtainable in a single operation are shown in the accompanying tables.

Drawn shapes. In drawing or forming the force applied exceeds the elastic limit of the metal without exceeding its tensile strength, causing permanent deformation.

1. When deep draws are required (i.e., cup diameter is less than 40% of blank diameter) not only are successive draws required, but it is often necessary to anneal the metal between draws.

2. On shallow draws, radii at the bottom of the drawn shape are usually three or four times the thickness of material, and radii under flanges are four to six times the thickness of material. Large flanges make it difficult to gather metal from the outside of the blank, and several operations may be needed to achieve a comparatively shallow draw.

3. Additional operations will produce a wider range of radii, and a flatter bottom on drawn parts.

4. The punch should cover about 60% of the blank area in any single draw. This means a ratio of depth to diameter of about 45%.

5. Unless a drawn part with variation in height of ±10% of depth is satisfactory, the part will have to be trimmed. Pinch trimming can be combined with other operations, but leaves a sharp edge.

6. The bottom of a cup cannot be drawn thinner than the side walls, but ironing can make cup walls 15% thinner than the bottom. Side walls may also be partially ironed to give steps.

7. Square or rectangular drawn shapes are more costly to tool.

8. Deep parts usually require a draft of 0.0005 to 0.0025 in. per in.

9. I.d. tolerances are affected by draft and out-of-roundness; dimensions thus affected are averaged in determining whether a part meets specified tolerances.

10. Drawing slant-wall shapes, like cones, calls for a greatly increased number of operations and should be specified only when vitally necessary.

11. If aluminum, zinc, or copper drawn symmetrical shapes are required, consider impact extrusions made in presses.

Roll Formed Shapes

Roll formed shapes have been produced from material ½ to ¾ in. thick, but usually the material used in roll forming is less than 0.125 in. thick. Roll forming machines are capable of handling sheet and strip varying in width from a fraction of an inch up to as much as 80 in., though most shapes are made from material less than 20 in. wide.

Dimensional tolerances must be comparatively liberal, primarily because of variations in the thickness of the raw material. Usually dimensional tolerances of ±0.002 in. must be allowed.

Short Run, Press Formed Parts

In the past, stampings and press formed parts could only be considered when huge quantities of parts were required. During the past few years, however, new techniques have been developed to extend the advantages of press forming to relatively small quantities of parts. These methods utilize soft die materials (which are easily worked but have short service lives), rubber blankets, or flexible punches or dies. These materials reduce die costs sufficiently to permit amortization of costs over comparatively small quantities of finished shapes.

RECOMMENDED LIMITATIONS FOR RUBBER PAD FORMING

Metal →	Heat Treatable Aluminum Alloys		Austenitic Stainless Steels	
	0	-T	Annealed	¼ Hard
Max Sheet Thickness, in.	0.187	0.064	0.078	0.032
Recommended Flange Width (straight, not >90 deg), in.*	1/16+	1/16+	3/16+	
	2.5 T	4 T	4.5 T	⅓
Max Metal Thickness for Forming Flanges, in.				
Stretch Flanges	0.125	Special methods required	0.050	0.016–0.030
Lightening Hole Flanges	0.125	0.064	External 0.060, internal 0.050	External 0.040, internal 0.030

*T = metal thickness.

PERMISSIBLE STRETCH IN PRESS-DIE AND HYDROPRESS RUBBER FORMING STRETCH FLANGES (%)

Aluminum Alloys	
2024 (-O or as quenched)	18[a], 12[b]
7075 (-O or as quenched)	18,[a] 12[b]
2024-T	12[a], 8[b]
7075-T	7[a]
6061-O, 5052-O	30
Stainless Steels	
301, 302, 304, 305, 308 (annealed)	40
321, 347, 316, 330 (annealed)	30
301, 302 (¼ hard)	25
301, 302 (½ hard)	10

[a]Routed edge. [b]Sheared edge.

Rubber pad. In the rubber pad or Guerin process, a rubber block or pad in the head of the press is used as the second die member to form a sheet metal blank around a punch or form block.

Flexible female die. One method is typified by the Hydroform press, which uses a flexible diaphragm covering a cavity filled with hydraulic fluid. The other method, the Marform press, utilizes a solid rubber pad which holds the blank, while regulated hydraulic pressure allows the punch to move into the pad, forming the part.

Flexible punch. Water or soluble oil is used as the male die member to force the sheet metal to conform to the configuration of the female die.

Drop hammer forming. Zinc-base alloys and lead are normally used for the dies since their low melting points permit rapid and economical fabrication of tools. In simple drop hammer work, there is no hold-down force on the blank; therefore, commonly encountered shapes have flanges and shallow depressions rather than drawn recesses. Parts are formed rather than drawn. Relatively deep draws can occasionally be accomplished with auxiliary devices and fixtures. Reverse contours and saddleback shapes are particularly difficult to form with a drop hammer.

RECOMMENDED SINGLE DRAW LIMITATIONS FOR MARFORM PROCESS

Cup Dia, in. ↓	Max Depth of Draw at Indicated Pressure, in.		Min Thickness, in.
	6000 psi	12,000 psi	
1	⅓	¾	0.008
2	⅔	1½	0.010
3	1	2¼	0.015
4	1⅓	3	0.020
5	1⅔	3¾	0.025
6	2	4½	0.030
7	2⅓	5¼	0.035
8	2⅔	6	0.040

MAXIMUM CUP DEPTH IN MARFORM PROCESS*

Metal Thickness, in. ↓	Max Cup Depth, in.
0.064	5⅛
0.050	4⅞
0.037	4¾
0.032	4½

*Based on reduction from 12-in. dia blank to 4¼-in. dia cup, 15,000 psi forming pressure.

Patterned Sheet Metal

Type →	Coined	Embossed	Perforated	Expanded
How Obtained	Cold rolling with male or female pattern engraved on hardened, forged steel roll and impressed on one side of sheet only	Cold rolling with male pattern engraved on one steel roll and matching female pattern on other, i.e., pattern is impressed three-dimensionally	High speed stamping or punching operation	Spitting and cold drawing in continuous patterns
Advantages	Hide marks, blemishes, scratches; reduce friction on slides, etc.; less costly than Embossed	Advantages of Coined sheet plus increased strength by redistribution of metal (see below); increased surface for heat transfer applications	Allow passage of air and light; visibility for inspection of enclosure; inexpensive	Advantages of Perforated, plus increased strength and possibility of more varied patterns
Remarks	No strong evidence of increased mechanical properties; often used for decorative strip with complex pattern design	Some patterns increase rigidity as much as 108%, impact resistance 39% and yield strength 92%	Mechanical strength decreased; formability increased	Openings can be varied from 1/16 to 4 in. to suit function and appearance
Materials	Steel, aluminum, stainless steel in sheet and strip. Copper, bronze, brass, nickel silvers in strip	Mostly stainless steel, low carbon steel, and aluminum alloys. Some strip in copper alloys; some titanium	Mostly low carbon steel, aluminum and tin	Aluminum, steel, stainless steel, monel, copper, brass
Sizes	Sheet: 18 to 72 in. x 6 to 24 ft x 0.025 to 0.125 in. Strip: 4 to 6.5 in. x 0.010 to 0.093 in.	5 to 52 in. x 6–16 ft x 0.018 to 0.250 in.	Steel: 16 to 26 gage; 36 x 96 to 48 x 120 in. Aluminum: 14 and 18 gage; 36 x 96 and 36 x 120 in.	14 to 28 gage; 36 x 72 to 48 x 120 in.
Patterns	Unlimited; mostly fluted, pebbled, stippled, ribbed, and stucco. Depth ranges from 0.002 to 0.015 in., generally about 0.007 in.	Large variety; mostly wood or leather grained, diamond, square, and same as coined. Depth ranges from 0.002 into corrugated patterns	Round holes and rounded end slots parallel either to width or length	Almost all diamond-shaped patterns but some woven or wire-fence type patterns
Uses	Decorative applications; materials handling slides; appliance, architectural and furniture trim; jewelry; fish lures	Same as Coined; heat exchangers; fluid transmission units; applications requiring greater strength than Coined	Decorative applications; ventilating panels and covers; guards; baskets; partitions and trim	Same as Perforated; grills; sound absorbent units; enclosures; automotive and aircraft uses requiring strength

"Patterned" is used here to include coined, embossed, perforated and expanded sheet and strip.

Advantages. Essentially the materials are intended for decorative use. In the case of flat sheet metal used over a large area, they prevent kinking and "oil-canning." They also diffuse light, eliminating harsh highlights on polished materials, or telltale highlights on distorted materials. In some cases they provide added strength and rigidity, or allow the use of lighter gage stock. Any changes in mechanical properties depend on the particular process, material and pattern.

Finishes. Most sheet metal products must be finished after fabrication, usually by some type of polishing or coating. The same end result can often be achieved more economically by using patterned sheet instead. Broad decorative and protective possibilities can also be achieved by judicious use of coatings over patterns. Colored textured metal is an outstanding example; the color may be applied by coating with pigment and baking, or by vacuum metallizing.

Design Rules. Patterned metals can be fabricated with standard tooling used for flat sheet metals. Depending on the alloy used, the materials can be blanked, punched, formed, stamped, moderately drawn, roll formed, lock-seam joined, riveted, soldered and welded.

Only for embossed sheet is any modification of standard techniques required:

1. Die clearance should be adjusted for cross-sectional thickness.
2. Bend radii should be at least twice the cross-sectional thickness unless bend lines fall along apexes of the design.
3. For severe bends the axis of bend should run at right angles to the pattern direction.
4. Draws under 1 in. will not usually cause pattern distortion, but actual depth of draw possible depends on pattern.
5. For resistance welding, copper wire braid can be laid between electrode and embossed pattern to form a nest.

Forgings

Cold Headed Parts

General. Cold headed parts are produced in a cold header, essentially a punch press laid on its side. Wire up to about 1 in. in dia is fed into the machine where it is automatically cut to size and positioned in the die with one end protruding from the die face. This end mushrooms out under the force of a punch; the head is formed between the die and punch faces.

Uses. Cold headed parts are economical when mass produced. The majority are mechanical fasteners which are produced at the rate of billions per year by each manufacturer.

Advantages.

1. Grain of the metal follows the contours of the part, avoiding surface weakening.
2. Alloys used are tough, ductile and resistant to cracking.
3. The required corner fillets increase fatigue strength.
4. Surface finish is excellent.
5. No stock is cut away.

Disadvantages.

1. Part must be shaped for extraction from the die.
2. There is a limit to the head volume and shape that can be upset without annealing.
3. Internal stresses may be left at critical points.
4. Size of parts is limited by capacity of cold headers.

Materials. Choice of a metal depends on the heading characteristics of the metal as well as the expected end service. Low and medium carbon steels, some alloy steels and brasses, and some aluminum alloys are most common. Other materials that have been cold headed include: beryllium copper, phosphor bronze, silicon bronze, nickel silver, monel, lead, zinc, silver and gold.

Design Rules

1. Head must taper evenly above and below point of maximum diameter.
2. A widely-spread thin head is more difficult to form.
3. Head heights should be between ¼ and ¾ of wire diameter.
4. Recessed heads require severe forming.
5. Embossing the top of the head increases costs.
6. Concentric heads are easiest to form.
7. Fillets must be provided on corners.
8. Allowable shank reduction is 60% or less.

Tolerances. The best guide to tolerances on cold headed parts are the standards developed by the American Society of Mechanical Engineers for cold headed bolts, screws and rivets. In general, shank diameters are held to ±0.003 in., head dimensions to ±0.005 in., and lengths to ±1/32 in.

Open Die Forgings

Modern open die forging employs mechanical hammers or presses. Each part is heated several times and shaped individually by a highly skilled operator; therefore production rates are low. The major advantages are simplicity of tooling and the wider range of part sizes possible. Shapes are generally simple, and tolerances are much wider than for closed die forgings.

Closed Die Forgings

General. Closed die forgings are produced by shaping hot plastic metal within closed dies; processes include drop, press or upset forging.

Drop forgings—A hammer forces the metal into the die by a series of impact blows. Major advantage is the speed of operation. These forgings are made in weights ranging from less than an ounce to several hundred pounds.

Press forgings—Similar to drop forgings but produced by squeezing in mechanical or hydraulic presses. Particularly adapted to symmetrical parts requiring one or two operations.

Upset forgings—Also produced by squeezing, but the dies grip the stock as well as form the impression. Upset forging is a hot forming process similar to cold heading, but can be used to produce parts weighing from a few ounces up to 500 lb.

Design rules. Dies must shape the part in the easiest possible manner, control the direction of flow, and hold required tolerances. For a large part, several dies may be required. Die blocks are usually made from alloy steel that has been forged to provide uniform properties. Some general design rules are:

1. Divide the impression as equally as possible between the top and bottom dies.
2. Keep the parting line in one plane if possible.
3. Taper the vertical sides to allow removal of the forging.
4. Avoid sharp radii and use fillets where possible.
5. Design ribs as low and wide as possible because they require a corresponding thin pocket in the die.
6. Generous sweeps and maximum draft angles should be provided for sections having a recess because they require that a corresponding raised section be machined into the die. (Raised sections wear rapidly because they get hotter.)
7. Group multiple forgings in die in such a way as to minimize preforming and flash.
8. Where possible, forge two interdependent parts together (e.g., bevel gears and pinions) to reduce die costs and material required.
9. In ring forging, pierce the pancake in such a way that the material removed can be used to produce a smaller ring, thus saving material.

continued on next page

Forgings

SHRINKAGE AND DIE WEAR TOLERANCES*

Length or Width, in. ↓	Shrinkage		Max Net Wt, lb ↓	Die Wear	
	Commercial, in. ±	Close, in. ±		Commercial, in. ±	Close, in. ±
1	0.003	0.002	1	0.032	0.016
2	0.006	0.003	3	0.035	0.018
3	0.009	0.005	5	0.038	0.019
4	0.012	0.006	7	0.041	0.021
5	0.015	0.008	9	0.044	0.022
6	0.018	0.009	11	0.047	0.024
For Each Additional Inch Add	0.003	0.0015	For Each Additional 2 Lb Add	0.003	0.0015
For Example:			For Example:		
7	0.021	0.011	13	0.050	0.026
12	0.036	0.018	21	0.062	0.031

*Shrinkage and die wear tolerances shall not be applied separately. They shall be applied as the sum of the two and shall be measured in such a way as to eliminate draft or variations in draft. They apply to that part of the forging formed by a single die block, and to no dimension crossing the parting plane.

DRAFT ANGLE TOLERANCES

Type →	Drop Forgings		Upset Forgings	
	Outside, deg	Inside Holes, deg	Outside, deg	Inside Holes, deg
Nominal Angle	7	7 or 10	3	5
Commercial Limits	0–10	0–13	0–5	0–8
Close Limits	0–8	0–8	0–4	0–7

QUANTITY TOLERANCES*

No. of Pieces on Order ↓	Over-Run, pieces	Under-Run, pieces	No. of Pieces on Order ↓	Over-Run, %	Under-Run, %
1–2	1	0	100–199	10	5.0
3–5	2	1	200–299	9	4.5
6–19	3	1	300–599	8	4.0
20–29	4	2	600–1249	7	3.5
30–39	5	2	1250–2999	6	3.0
40–49	6	3	3000–9999	5	2.5
50–59	7	3	10,000–39,999	4	2.0
60–69	8	4	40,000–299,999	3	1.5
70–79	9	4	300,000 up	2	1.0
80–99	10	5			

*Quantity tolerances shall be the permissible over or under-run allowed for each release or part shipment of an order. Any shipping quantity within the limits of over and under-run shall be considered as completing the order. Commercial and close tolerances shall be the same amounts.

THICKNESS TOLERANCES*

Max Net Wt, lb ↓	Commercial, in.		Close, in.	
	Minus	Plus	Minus	Plus
0.2	0.008	0.024	0.004	0.012
0.4	0.009	0.027	0.005	0.015
0.6	0.010	0.030	0.005	0.015
0.8	0.011	0.033	0.006	0.018
1.0	0.012	0.036	0.006	0.018
2.0	0.015	0.045	0.008	0.024
3.0	0.017	0.051	0.009	0.027
4.0	0.018	0.054	0.009	0.027
5.0	0.019	0.057	0.010	0.030
10.0	0.022	0.066	0.011	0.033
20.0	0.026	0.078	0.003	0.039
30.0	0.030	0.090	0.015	0.045
40.0	0.034	0.102	0.017	0.051
50.0	0.038	0.114	0.019	0.057
60.0	0.042	0.126	0.021	0.063
70.0	0.046	0.138	0.023	0.069
80.0	0.050	0.150	0.025	0.075
100.0	0.058	0.174	0.029	0.087

*Thickness tolerances for drop hammer forgings apply to the over-all thickness measured in a direction perpendicular to the fundamental parting plane of the dies. For upset forgings, thickness tolerances apply to the metal actually enclosed and formed by the dies, measured parallel to the direction of travel of the ram.

FILLET AND CORNER TOLERANCES*

Max Net Wt, lb ↓	Commercial, in.	Close, in.
0.3	3/32	3/64
1.0	1/8	1/16
3.0	5/32	3/64
10.0	3/16	3/32
30.0	7/32	7/64
100.0	1/4	1/8

*Fillet and corner tolerances apply to all intersection surfaces, even though drawings or models indicate sharp corners. If such drawings or models have or indicate fillet or corner dimensions of larger radii than these standards, such larger dimensions shall be considered as actually specified and the tolerances shall be "special tolerances."

Where a corner tolerance applies on the meeting of two drafted surfaces, the tolerance shall apply to the narrow end of such meeting and the radius will increase toward the wide end. The total increase in the radius will equal the length of the drafted surface in inches, multiplied by the tangent of the nominal draft angle.

Materials. One of the principal advantages of forgings is the wide range of materials that can be employed. All materials must have these requirements in common: the forging stock (billet, bloom, bar or extrusion) must be hot workable and must be internally sound and free from surface defects. Following is a list of the major classes:

Carbon steels—Low carbon (up to 0.25%) forgings for moderate conditions and for carburized parts where resistance to abrasion is important. Medium carbon (0.30 to 0.50%) forgings for more severe service; some heat treatment is generally desirable. High carbon (> 0.50%) forgings for hard surfaces and springs; heat treatment is essential to obtain other desired properties.

Alloy steels—Manganese, nickel, nickel-chromium, molybdenum, chromium, vanadium, chromium-vanadium, tungsten, silicon-manganese. Forgings from these steels are used wherever higher strength, resistance, durability, etc., are wanted. The proper selection of a particular composition, together with its subsequent heat treatment, depends upon the particular service requirements of the part.

Corrosion and heat resisting, and stainless, steels—These steels are usually high in chromium or nickel, or both. The particular type of corroding agent to be encountered determines the best composition. Generally, but not necessarily, forged surfaces should be polished to obtain full benefit of corrosion resistance properties.

Iron—Wrought iron and ingot iron are forged for special applications where ductility is required. Wrought iron furnishes a moderate degree of corrosion resistance. The copper-bearing irons and low carbon steels are in this class.

Copper, brasses, bronzes—Copper forgings have extensive applications in the electrical field. The brass and bronze alloys have moderate corrosion resistance properties. Some of the bronzes have moderately high strength and good bearing properties.

Nickel, nickel-copper alloys—Pure nickel is forgeable. The alloy of nickel and copper known as monel metal offers a desirable combination of strength, toughness and corrosion resistance.

Light alloys (aluminum, magnesium)—The light alloys have about one-third the weight of steel, and some have approximately the strength of low carbon steel. Forgeable alloys are available in both the aluminum and magnesium groups.

Titanium—Titanium and its alloys have been forged for the production of aircraft components. Special dies are necessary and intricate forgings require more stages than steel.

Commercial forging practice. Impression die forgings are sold by the piece and not by the pound. It is understood without specific mention that the excess metal or flash of forgings shall be removed by trimming, and that forgings shall be free from injurious defects.

Quantity—The quantity specified permits standard practice limits on over-runs and under-runs.

Size—Forgings within commercial size limits will be furnished unless closer tolerances are specified.

Coining or sizing—Closer tolerances may be obtained by additional hot or cold sizing operations.

Surfacing conditions—Forgings are furnished in a cleaned condition obtained by tumbling, pickling or blast cleaning unless otherwise specified.

Special requirements—Any special requirement, such as heat treatment or special tests, should be clearly stated.

Preparation charges—The production of impression die forgings requires the preparation of special dies and tools which may be charged to the customer as a separate item called "preparation charges." The customer has the exclusive right to use such dies and tools, but because the full cost is generally not included in such a charge he does not have the right to remove them without additional payment. Any such dies and tools are maintained in the future without further charges to the customer.

Tolerances. Standard tolerances given on these pages are for forgings up to 100 lb.

Special tolerances may be specified when regular tolerances are not applicable. Regular tolerances, shown here, are classed as "Commercial Standard" and "Close Standard."

MISMATCHING TOLERANCES*

Weight of Part ↓	Commercial, in.	Close, in.
Net Weight up to—		
1 Lb	0.015	0.010
7 Lb	0.018	0.012
13 Lb	0.021	0.014
19 Lb	0.024	0.016
Each Additional 6 lb Add	0.003	0.002
For Example:		
37 Lb	0.033	0.022
55 Lb	0.042	0.028

*Mismatching tolerances are independent of, and in addition to, any other tolerances. Mismatching is the displacement of a point—in that part of a forging formed by one die block of a pair—from its desired position when located from the part of the forging formed in the other die block of the pair. Mismatching does not include any displacement caused by variation in thickness of the forging, but is only the displacement in a plane parallel to the main or fundamental parting plane of the dies.

Metal Powder Parts

General

Metal powder parts are made by compacting loose metal powders in a die and subsequently sintering the compact to form a structural part. Additional operations may be used to obtain special results.

Materials. Materials combinations impossible by other processes are commonplace in metal powder parts. Among the materials used are: iron, steel, stainless steel, copper, brass, bronze, monel, nickel, tin, tungsten, zirconium, graphite, and various oxides and carbides. Powders of these materials are produced by a variety of methods, the most common being reduction of oxides or ores, electrolytic deposition, atomizing, mill grinding and thermal decomposition of carbonyls.

Advantages. Powder metallurgy permits the use of metallic combinations that would not be possible to melt, and permits close control over structure, which may be dense or porous as desired.

Limitations. Metal powder parts must be of relatively simple shape because: 1) dies must permit easy removal of parts, 2) most powders have poor flow qualities, and 3) it is difficult to transmit pressures through great depths of powder. Where other considerations make it practicable, more complex shapes can be produced by using costly, intricate dies and double-acting presses. Because powder metallurgy is not capable of holding extremely close dimensional tolerances, secondary sizing or coining operations are sometimes required. Size of metal powder parts is restricted both by available press sizes and by the difficulty of transmitting pressure through powder. Initial tool costs are high. Production volumes of less than 50,000 parts are normally not economical although there are cases where 10,000 parts or less have proved feasible.

Mixing. The powders are mixed with alloying additives and lubricants. In rare cases (e.g., preparation of prealloyed powders) thermal treatment may be required before compacting.

Compacting. Compacting (or pressing) to proper density and shape requires pressures of from 5 to 50 psi in mechanical or hydraulic presses. The dies are usually made of hardened tool steel or cemented carbides and must be lapped to a high polish.

Sintering. This operation is performed at a temperature which is usually 70 to 80% of the melting point of the major constituent. Sintering time ranges from ½ hr to several hours. Volatile materials are driven off and, if present in quantity, can result in porosity. The furnace atmosphere must be carefully controlled to prevent oxidation.

Infiltrating. In this additional step, sometimes desirable, a molten metal of lower melting point than the major constituent is forced into the part under pressure, penetrating and solidifying within the pores. Infiltration increases strength by 70 to 100%.

Other operations. Presintering may be used before parts are machined. Coining (or sizing) is often used to provide closer tolerances and increased strength; pressures used are equal to or greater than the initial pressure. Other operations possible include machining and case or precipitation hardening. A common finishing process is the introduction of oil into the pores of bearings.

Properties of the Powders

The properties of metal powder parts are highly dependent on the qualities of the powders used. The most important of these are:

Purity. Clean particle surfaces insure good contact between particles (needed for optimum mechanical properties). The presence of foreign particles must to be held to a minimum, usually specified.

Apparent density. Apparent density (sometimes bulk density) is the weight of a unit volume of powder and is of particular importance in the pressing operation. The lower the value, the greater the volume of powder needed for a part of given size.

Compressibility. The ability of a metal powder to be pressed is important for both fabrication and end properties. Compressibility (ratio of volume of loose powder to volume of compact) is affected by physical characteristics of powder particles and distribution of particle size.

Particle size distribution. Also called sieve analysis, this property is usually expressed as the percentage by weight of powder that can be retained on each of a series of standard sieves of decreasing size. It affects press feed, dimensional changes during sintering, porosity of the compact, and final attainable density and strength.

Flow rate. The ease with which a metal powder can be fed into the die is determined by its flow rate. Low flow rates slow up automatic pressing operations and may require the use of vibrating equipment.

Sintering properties. Sintering is usually done in an inert, reducing or neutral atmosphere, or in a vacuum. The sintering temperature of metal powders is critical; therefore, for production purposes it is desirable to have a furnace with a reasonably wide temperature range.

Green strength. This is the powder's ability to be handled without breakage after compacting and before sintering.

Properties of the Parts

Mechanical and physical properties of sintered parts are closely related to the final density that can be achieved. In general, as density of a metal powder part increases, strength also increases, and at 100% density the properties theoretically will be at least equal to those of solid stock.

As yet, few standard tests for determining mechanical properties have been established, and in many cases conventional methods are not adequate. In addition, it is not feasible to give detailed information concerning strength properties because they depend on so many variables (e.g., type and size of powder, pressing pressure, sintering temperature, coining and other operations). The table included here is a rough guide to the strength ranges that can be expected with the most common metal powder formulations.

Production Factors

Metal powder parts may be classified in order of increasing difficulty of production according to each of three factors: design, tolerances and density.

Design classification. I—plain circular or profiled parts, II—plain circular or profiled parts with holes,

III—parts with external flanges, IV—parts with internal flanges, V—parts requiring multiple punch motions.

Tolerance classification. a—wide, b—medium, c—narrow.

Density Classification. 1—low (below 6.3 gm per cu cm), 2—medium (from 6.3 to 7.1 gm per cu cm), 3—high (above 7.1 gm per cu cm).

Thus, difficulty in producing metal powder parts ranges from Ia1 to Vc3.

Design Factors

Wall thickness. A wall as thin as 0.030 in. is possible on small parts, but a general rule calls for a minimum thickness of 0.032 in. per in. of length of the section. Large variations in section thickness are undesirable.

Tolerances. There are two different classes of tolerances for metal powder parts: tolerances on dimensions which are tool dependent only, and tolerances that are dependent on both press and tool (generally only the overall dimension in the pressing direction). The accompanying table illustrates that the narrowest tolerances are obtainable only if the last processing step involves a sizing or coining operation, and in some cases a precipitation hardening treatment. These narrow tolerances compare with medium grinding or broaching tolerances. Tolerances for parts that are sintered but not sized compare with medium to wide tolerances for screw machine or milled parts.

Design Rules

1. Cylinders, squares and rectangles are the most favorable shapes. When a shape deviates from these, it is essential that it be uniform in the direction of pressing.

2. Contours must be in a plane at right angles to the direction of pressing.

3. Avoid feather or knife edges; narrow, deep splines; thin projections; and sharp corners.

4. Radii of at least 0.010 in. should be provided in corners, and edges should be given a 45-deg chamfer.

5. Length of part in pressing direction is normally limited to 3 to 6 times the cross sectional area.

6. Use inserts sparingly as they are difficult to mold in.

7. Shoulders in a solid top punch require 1 to 5 deg taper to assist removal.

8. To prevent trapping powder in an acute angle between punch and die, a small horizontal step is recommended.

9. Use flat punches for less breakdown time.

10. An acute angle for a lead-in can sometimes be produced by a coining operation.

11. Undercuts cannot be molded.

12. Parts with multiple steps should be designed with a minimum width of 0.035 in. for each step.

13. Complete spheres cannot be molded.

14. Avoid re-entrant angles.

15. If a projection is opposite the blind end, one or the other must be modified.

16. Grooves in top face of parts can be molded within following limits: 30% of total height for curved grooves, 20% for square. A 5-deg min taper is necessary on vertical sides.

17. Avoid flats on flanges requiring thin punches.

18. Avoid vertical radii on edges.

19. Joining metal powder parts offers special difficulties.

20. Corrosion protection requires special precautions.

TOLERANCES FOR METAL POWDER PARTS

Final Operation ↓	Tolerances, in. per in.[a]		
	Narrow	Medium	Wide
Coining[b]	0.0052, —	0.00208, 0.00132	—, 0.0052
Sintering	—, —	0.00208, 0.00326	0.0084, 0.0208
Case Hardening	—, —	0.00208, 0.0052	0.0208, 0.0208

[a] The first tolerance refers to dimensions which are tool-dependent only; the second to those which are both tool and press-dependent. A dash means the particular class of tolerance is not held.
[b] And possibly precipitation hardening.

PROPERTIES OF SOME COMMON TYPES OF METAL POWDER PARTS

Material[a]	Composition, %	Density, gm/cu cm	Ten Str, 1000 psi	Hardness (Rockwell)	Elong (1 in.), %	Compr Yld Str, 1000 psi[b]
Iron		6.5	22–26	F20–30	2–5	18–21
Iron		7.3	35–38	B15–25	20–28	29–34
Iron-Copper	Cu 1.5–2.5	7.0	35	B30–50	10	26
Iron-Copper-Carbon	Cu 1.5–2.5, C 0.25–0.60	7.0	42	B35–60	7	38
Iron-Copper-Carbon	Cu 1.5–2.5, C 0.6–1.0	7.0	50	B60–80	5	48
Iron-Carbon	C 0.25–0.60	6.5	27	B20–30	2	23
Iron-Carbon	C 0.6–1.0	7.0	48	B55–75	3	45
Iron-Carbon	C 0.6–1.0	6.5	35	B35–45	½	27
Infiltrated Iron	C 0.25	7.3	65	B55–65	1	70
Infiltrated Iron	C 0.6–1.0	7.3	100	B65–75	0.5	120
Stainless Steels	304 and 316	6.0–6.5	40–75	F64–85	12–25	—
Copper		8.3	26–27	H30–40	16–23	20–22
Brass	Cu 78.5, Pb 1.5	7.5–7.8	29–33	H72	16–29	14–18
Bronze	Sn 9.5–10.5	6.8–7.2	16–20	H65–90[c]	2–3	15–20
Nickel Silver		7.5–7.8	23–31	H78–80	7–15	19

[a] Annealed condition except bronze. [b] At 0.1% offset. [c] Depends largely on degree of cold working.

Screw Machine Parts

General

Advantages. Perhaps the greatest advantage of screw machine parts is the extreme speed at which they can be produced. Production rates can reach—and even exceed—4000 parts per hr. Extremely close tolerances can be held. Finishes are usually superior to those attained by other methods. Since bar or tube stock is used as the raw material, mechanical properties are usually high.

Limitations. Scrap losses are usually high because the over-all size of the bar must be as great, or greater than, the largest diameter of the part.

Materials. Nearly any machinable metal can be used for screw machine parts if it is available in bar or tubular form. For best results, though, the material should be free machining and should not be too soft, too hard or too stringy (since such materials make it difficult to maintain production speeds and also cause inferior surface finish). The majority of screw machine parts are made from free-machining steels, free-cutting brasses, and aluminum and magnesium alloys.

Design Rules

Restrictions are imposed by the requirement that all parts must have surfaces of rotation that are concentric with the axis of the stock being machined. However, interior and exterior undercuts are possible, and nearly any type of thread can be produced.

Square corners are not desirable. Chamfers are preferred, but if rounded edges are desired, liberal radii should be provided. Dimensions can be held to ±0.001 to ±0.003 in. without difficulty and, when necessary, they can be as close as 0.0005 in.

Maximum size is limited, but screw machine parts can be extremely small. The range of sizes normally encountered is ¼ in. up to 8 in. in dia, and a fraction of an inch up to 6-8 in. in length.

MACHINABILITY RATINGS (Based on AISI B1112 — 100)

Aluminum Alloys (wrought)	
3003	Soft
2011	Excellent
2014	Average
2017	Average
2018	Average
2024	Average
6151	Soft
5052	Soft
5056	Average
6061	Soft
6063	Soft
7075	Average
Aluminum Alloys (cast)	
43	Soft
85	Soft
108	Soft
113	Average
122	Excellent
138	Average
142	Average
195	Average
212	Average
214	Average
220	Excellent
319	Soft
355	Soft
380	Soft
750	Excellent
Coppers	
Copper, 99.9%	40
Electrolytic Tough Pitch	40–50
Leaded Copper	160
Oxygen-Free Copper	40
Phosphorized Copper	40
Selenium Copper	180
Tellurium Phosphorized Coppers	180
Copper Alloys	
Aluminum Bronze (alpha), 92–95%	60–80
Copper Alloys (cont'd)	
Aluminum Bronze (duplex)	60–100
Architectural Bronze, 58%	180
Beryllium Copper, 97%	40
Cartridge Brass, 70%	60
Commercial Bronze, 90%	40
Forging Brass, 60%	160
Free Cutting Brass, 61.5%	200
Gilding Bronze, 95%	40
Gun Metal (cast), 95.8%	60
High Leaded Brass, 62%	180
Leaded Commercial Bronze, 89%	180
Leaded Naval Brass, 60%	140
Leaded Nickel Silver, 46%	160
Leaded Phosphor Bronze (B_1)	100
Leaded Phosphor Bronze (B_2), 94%	200
Leaded Silicon Bronze, 95.6%	120
Low Brass, 80%	60
Low Leaded Brass, 64%	140
Manganese Bronze, 59%	60
Muntz Metal, 60%	80
Naval Brass, 60%	60
Nickel Silvers	40
Phosphor Bronze, 92% (Grades A, C, D, E)	40
Red Brass, 85%	60
Silicon Bronze, 95.8%	60
Irons	
Cast Iron	
Soft	80
Medium	65
Hard	50
Ingot Iron	50
Irons (cont'd)	
Malleable Iron	
Standard	120
Pearlitic	80
Wrought Iron	50
Magnesium Alloys	
(wrought)	500–2000
Nickel and Its Alloys	
Nickel	20
Nickel Alloys (rolled)	40–55
Monel (cast)	35
Monel (rolled)	40–55
Monel, K	40
Screw Machine Steels	
SAE 1120 (leaded)	140
SAE X1112	140
SAE 1112	100
SAE X1314	90–95
SAE X1315	90–95
SAE 1120	70–75
SAE X1335	70–75
SAE X1350	70–75
Carburizing Steels	
SAE X1020	50–65
SAE 1025	50–65
SAE 1020	50–65
SAE 1015	50–65
SAE 6120 (annealed)	45–50
SAE 6115	45–50
SAE 3115	45–50
SAE 4615 (annealed)	45–50
SAE 2315 (annealed)	45–50
SAE 3215	45–50
Heat Treating Steels	
SAE 1035	55–60
SAE 1040	55–60
Heat Treating Steels (cont'd)	
SAE 1045 (annealed)	55–60
SAE 4130 (annealed)	40–50
SAE 4140 (annealed)	40–50
SAE 3140 (annealed)	40–50
SAE 6135 (annealed)	40–50
SAE 6140 (annealed)	40–50
SAE 6150 (annealed)	40–50
SAE 1335 (annealed)	40–50
SAE 1350 (annealed)	30–40
SAE 2330 (annealed)	30–40
SAE 2345 (annealed)	30–40
SAE 3140	30–40
SAE 2345	30–40
SAE 52100 (annealed)	30–40
Stainless Steels	
Type 405	55
Type 406	50
Type 430	50
Type 442	60
Type 443	60
Type 446	65
Type 430-F	90
Type 403	50
Type 410	50
Type 414	60
Type 416	85
Type 420	50
Type 420-F	70
Type 431	54
Type 440	40
Type 501	70
Type 502	70
Type 302	35
Type 303	60
Type 304	45
Type 309	48
Type 316	46
Type 317	45
Type 321	50
Type 347	48
Zinc	200

Spinnings

ADAPTABILITY OF METALS TO SPINNING

Material ↓	Shallow Spinning	Deep Spinning
Group 1—Aluminum and Its Alloys		
1100-O	1.00	1.00
3003-O	1.00	0.99
2024-O	0.65	0.45
5052-O	0.80	0.55
6061-O	0.90	0.80
Group 2—Copper and Its Alloys		
Copper (cold rolled, annealed)	1.00	1.00
Copper (hot rolled)	0.99	0.88
Yellow Brass	0.99	0.92
Cartridge Brass, 70%	0.99	0.92
Low Brass, 80%	0.96	0.89
Red Brass, 85%	0.90	0.83
Commercial Bronze, 90%	0.88	0.80
Gilding, 95%	0.85	0.75
Admiralty	0.82	0.70
Naval Brass	0.75	0.45
Muntz Metal	0.55	0.30
Phosphor Bronze A	0.85	0.40
Phosphor Bronze C	0.85	0.45
Cupro Nickel, 30%	0.95	0.65
Nickel Silver A	0.95	0.65
Silicon Bronze	0.94	0.60
Group 3—Carbon and Low Alloy Steels		
Cold Rolled (deep drawing quality)	1.00	1.00
Vitreous Enameling (deep drawing and spinning quality)	1.00	0.95
Cold Rolled (standard)	1.00	0.92
Hot Rolled (pickled and oiled)	1.00	0.92
Hot Rolled (low carbon)	0.90	0.55
Hot Rolled (copper-bearing)	0.88	0.51
Lead Coated (long terne)	1.00	*
Galvannealed	1.00	*
Galvanized	0.90	*
High Strength	0.45	0.15
Carbon (0.40% and above)	0.25	0.10
Group 4—Stainless Steels		
Type 302	0.98	0.60
Type 304	0.98	0.90
Type 305 (free-spinning)	1.00	1.00
Type 309S	0.80	0.45
Type 316	0.90	0.60
Type 321	0.85	0.50
Type 347	0.90	0.50
Type 430	0.90	0.50
Group 5—Nickel and Its Alloys		
Monel (spinning quality)	1.00	0.90
Monel (special cold rolled, soft temper)	1.00	0.85
Inconel	0.90	0.70
Nickel (low carbon)	1.00	1.00
Nickel	1.00	0.92
Multimet N-155	0.90	0.50
Hastelloy A	0.75	0.35
Hastelloy B	0.70	0.30
Hastelloy C	0.50	0.10
Group 6—Miscellaneous Metals		
Lead	0.96	0.90
Pewter	1.00	0.99
Zinc	1.00	1.00
Tantalum	0.86	0.45
Magnesium	0.80	0.45
Molybdenum	0.55	0.15

*Impractical—coating flakes off.

Cold spinning is done by applying localized pressure to a rotating disk of sheet metal to draw it over a male form. The form is usually of hardwood, sometimes metal, and must be polished smooth or surface roughness will show in the finished part.

Advantages. Simple, economical operation for small-lot production, particularly for shapes that can be withdrawn directly from a one-piece chuck. Multi-section or offset chucks can be used.

Limitations. Considerable skill is required by the operator because the spinning tool (a rounded-end wood or metal tool, or roller) is held and manipulated manually. Usually there is some thinning of the material.

Design Factors. The tolerances held by spinning operations are often closer than for drawn parts. It is also possible to neck over collapsible forms certain parts that could not be produced by drawing or shaping in positive dies.

Materials. Most metals, with the exception of magnesium and molybdenum, can be cold spun. Metals such as gold, silver, platinum, Kovar, Invar and Illium can be spun but require special handling.

Adaptability. Adaptability of metals to the spinning process is rated in the chart given above. The unit 1.00 is assigned to the type of material in each group that lends itself most readily to cold spinning. The lower the index, the higher the cost. These figures will vary slightly with contour, gage and size.

This analysis applies to manual metal spinning by the cold method. Where quantities warrant special automatic spinning setups, or where existing automatic setups can be used, difficult-to-form metals can be deep spun readily. The deep spinning ratings in the table do not apply under these conditions.

Mechanical Tubing

General

Mechanical tubing is manuactured specifically for further processing into fabricated tubular products. It is of uniform high quality and produced to close tolerances. In addition, it usually has good machining qualities and relatively high finish, and is available in a wide range of materials, analyses, shapes and sizes.

The word "tubing" is used to describe several different products, including pipe and casing; however, it refers more specifically to seamless or welded tubular forms which are manufactured to closer size tolerances than pipe. Another distinction is that practically all pipe is round in section.

Advantages. For some parts, such as relatively long, thin-walled cylindrical objects, tubing is the only answer. On the other hand, there are many uses where tubing competes with bar, punchings, machined parts, weldments and castings. In such cases tubing may offer savings in weight, inherent structural strength, and reduction in fabricating time and costs, particularly in machining operations.

The applications of tubing are extended by its ability to be worked and fabricated into parts by many methods (e.g., bending, swaging, spinning, flaring, machining, joining). Because of this adaptability, it actually serves as a semifinished form which can be further shaped into the finished product. In many applications the forming is of such a nature that the tubing practically loses its identity as such.

Materials. Carbon, alloy and stainless steels; copper and copper alloys; nickel and nickel alloys; aluminum and its alloys; magnesium alloys; and titanium. In addition, specialty tubing is made from a number of other, less common materials.

Types. Tubing is produced either seamless or welded. Seamless has no longitudinal seam (however, seamless tubing is often joined end to end by a circumferential weld). Welded tubing is manufactured from flat stock and has a longitudinal seam. Some of the materials mentioned above can be produced only in seamless or only in welded tubing.

Comparisons. Seamless and welded tubing are alike in many of their characteristics, but differ in others. Welded tubing is made with relatively thin walls. Seamless is produced in a larger range of sizes and wall thicknesses, including heavy walls. Closer wall thickness tolerances can be maintained with welded tubing than with seamless.

In mechanical properties, as-welded tube is about equal to the flat stock from which it is formed. Its properties are generally lower than those of cold drawn seamless tubing because of the improvement in properties resulting from cold work. However, drawn welded tubing compares with seamless in its properties. Both welded and seamless tube are closely comparable in their forming characteristics.

TOLERANCES FOR TITANIUM TUBING[a]

Diameter, in.[b] ↓	Cold Drawn[c]		Extruded	
	O. D. Tol, in.	Wall Thk Tol, %	O. D. Tol, in.	Wall Thk Tol, %
Up to 1½	0.010[d]	10	—	—
1½ to 3½	0.010	10	—	—
3½ to 5½	0.015	10	0.031	14[e]
5½ to 8	0.030	10	0.047	12.5
8 to 10¾	—	—	0.063	12.5

[a] Round tubing. All values ±.
[b] Range is not inclusive of higher value.
[c] Welded or seamless; also welded with weld area cold worked.
[d] Some producers state 0.005 in. here.
[e] 12.5% if wall thickness is over 0.203 in.

Temper and finish. Tubing of most materials is furnished in a number of different conditions or tempers to meet specific forming or service requirements. It is also normally available in at least one or two standard finishes. The finishes depend upon the material and methods of manufacture. Where required, any one of a variety of special finishes can be had on order. For example, tubing can be obtained with a special inside surface, a special outside surface, or both. For applications such as plated parts, or parts requiring exceptionally smooth, uniform surfaces, the tubing can be furnished ground and polished.

Design Factors

Shape. By proper design of the part and careful selection of the shape and size of the tubing, machining and other shaping operations can be cut to a minimum. The most common shape is the round section. Square and rectangular sections are often produced as standard shapes in a wide range of sizes. The following are some of the special shapes that can be produced on order: embossed; fluted outside, plain inside; fluted; hexagon; lip; octagon; pinion (longitudinal serrations on outside); polygonal outside, plain inside; reeded; roped; rope-fluted; rope-reeded; round outside, polygonal inside; and twisted.

Cost. Tubing may cost more than bar stock, but savings in processing often offset additional materials cost. Thus, drilling operations can be eliminated, and drills replaced by simple, less expensive boring tools. Boring can be done faster than drilling; chucking pressures are reduced. There is also less tool wear and fewer tool changes.

Tolerances. Round tubing has three cross-sectional dimensions which must be considered in ordering and fabricating. They are outside diameter (o.d.),

DIAMETER TOLERANCES FOR CARBON AND ALLOY STEEL WELDED TUBING[a]

Diameter, in.[b] ↓	Wall Thickness, BWG	Cold Rolled Carbon Steel				Hot Rolled Carbon Steel		
		Standard Tolerance[c]		Close Tolerance[d]		Standard Tolerance[c]		Close Tolerance[e]
		O.D., in.	I.D., in.	O.D., in.	I.D., in.	O.D., in.	I.D., in.	O.D., in.
¼ to ⅜	22 to 14	0.0025	0.009	—	—	—	—	—
	20 to 14	—	—	0.002	0.005	—	—	—
	16 to 14	—	—	—	—	—	—	0.002
⅜ to ⅝	22 to 16	0.003	0.005	—	—	—	—	—
	20 to 12	—	—	0.0025	0.0025	—	—	—
	16 to 12	—	—	—	—	—	—	0.0025
	14 to 12	0.003	0.009	—	—	—	—	—
⅝ to 1⅛	22 to 14	0.0035	0.005	—	—	—	—	—
	20 to 11	—	—	0.0025	0.0025	—	—	—
	16 to 11	—	—	—	—	0.0035[f]	0.012[f]	0.0025
	13 to 11	0.0035	0.008	—	—	—	—	—
1⅛ to 2	22 to 14	0.005	0.006	—	—	—	—	—
	20 to 9	—	—	0.003	0.003	—	—	—
	16 to 14	—	—	—	—	0.005	0.010	—
	16 to 9	—	—	—	—	—	—	0.003
	13 to 9	0.005	0.008	—	—	—	—	—
	13 to 7	—	—	—	—	0.005	0.015	—
2 to 2½	20 to 14	0.006	0.007	—	—	—	—	—
	20 to 9	—	—	0.004	0.004	—	—	—
	16 to 14	—	—	—	—	0.006	0.012	—
	16 to 9	—	—	—	—	—	—	0.004
	13 to 9	0.006	0.009	—	—	—	—	—
	13 to 6	—	—	—	—	0.006	0.016	—
2½ to 3	20 to 18	0.008	0.012	—	—	—	—	—
	18 to 9	—	—	0.005	0.005	—	—	—
	16 to 14	—	—	—	—	0.008	0.012	—
	16 to 9	0.008	0.010	—	—	—	—	0.005
	13 to 4	—	—	—	—	0.008	0.016	—
3 to 3½	20 to 9	0.009	0.012	—	—	—	—	—
	16 to 14	—	—	—	—	0.009	0.015	—
	13 to 4	—	—	—	—	0.009	0.020	—
3 to 4	18 to 8	—	—	0.006	0.006	—	—	—
	16 to 8	—	—	—	—	—	—	0.006
3½ to 4	20 to 8	0.010	0.015	—	—	—	—	—
	16 to 14	—	—	—	—	0.010	0.017	—
	13 to 4	—	—	—	—	0.010	0.021	—
4 to 5	16 to 14	0.020	0.020	—	—	0.020	0.022	—
	13 to 8	0.015	0.018	—	—	—	—	—
	13 to 4	—	—	—	—	0.015	0.026	—

[a] Round tubing. All values are ±.
[b] Range is not inclusive of lower value.
[c] Flash controlled to 0.005-in. max.
[d] Mandrel flash removed.
[e] Without mandrel. Same values hold for cold rolled close tolerance without mandrel.
[f] Diameter range for this tolerance is actually ¾ to 1⅛ in.

inside diameter (i.d.), and wall thickness or gage. In seamless and drawn welded tubing each of the dimensions may vary independently; therefore it is important to have a knowledge of the tolerances to which the tubing is manufactured. This information can be found in the accompanying tables.

continued on next page

Mechanical Tubing

WALL THICKNESS TOLERANCES FOR CARBON AND ALLOY STEEL WELDED TUBING[a]

Wall Thickness		Wall Thickness Tolerance, in.[b]	
BWG	In.	Cold Rolled	Hot Rolled
22	0.028	+0.000, −0.003	—
20	0.035	+0.000, −0.004	—
18	0.049	+0.000, −0.004 to −0.005	—
16	0.065	+0.000 to +0.002, −0.004 to −0.007	+0.002, −0.006 to −0.010
14	0.083	+0.000 to +0.002, −0.004 to −0.007	+0.002 to +0.003, −0.006 to −0.012
13	0.095	+0.000 to +0.002, −0.004 to −0.007	+0.002 to +0.003, −0.006 to −0.012
12	0.109	+0.000 to +0.003, −0.006 to −0.009	+0.002 to +0.005, −0.006 to −0.012
11	0.120	+0.000 to +0.003, −0.006 to −0.009	+0.002 to +0.005, −0.008 to −0.012
10	0.134	+0.000 to +0.003, −0.006 to −0.009	+0.002 to +0.005, −0.008 to −0.012
9	0.148	+0.000 to +0.003, −0.006 to −0.009	+0.002 to +0.005, −0.008 to −0.012
8	0.165	+0.000 to +0.003, −0.007 to −0.010	+0.002 to +0.005, −0.008 to −0.012
7	0.180	—	+0.002 to +0.005, −0.008 to −0.012
6	0.203	—	+0.002 to +0.005, −0.010 to −0.013
5	0.220	—	+0.002 to +0.005, −0.010 to −0.013
4	0.238	—	+0.002 to +0.006, −0.010 to −0.018
—	0.250	—	+0.006 to −0.018

[a] Round tubing.
[b] Ranges are given because tolerance varies with o.d.

TOLERANCES FOR CARBON AND ALLOY STEEL SEAMLESS TUBING[a,b]

Diameter, in.[c] ↓	Finish Annealed		Soft Annealed	
	O.D. Tol, in.	I.D. Tol, in.	O.D. Tol, in.	I.D. Tol, in.
3/16 to 1/2	±0.004[e]	—	+0.006, −0.002	—
1/2 to 1 1/2	+0.005[d,e,f]	−0.005[d,e,f]	+0.008,[d,e,f] −0.002	+0.002,[d,e,f] −0.008
1 1/2 to 3 1/2	+0.010[d,e,f]	−0.010[d,e,f]	+0.015,[d,e,f] −0.005	+0.005,[d,e,f] −0.015
3 to 5 1/2	+0.015[d,f]	+0.005,[d,f] −0.015	+0.023,[d,f] −0.007	+0.015,[d,f] −0.025
5 1/2 to 8	±0.030[f,g]	±0.035[f,g]	±0.060[f,g]	±0.070[f,g]
	±0.020[h]	±0.025[h]	±0.040[h]	±0.050[h]
	+0.030[d]	+0.015,[d] −0.030	+0.045,[d,f] −0.015	+0.037,[d,f] −0.053
8 to 10 3/4	±0.045[f,g]	±0.050[f,g]	—	—
	±0.035[h]	±0.040[h]	—	—
	+0.045[d,f]	+0.015,[d,f] −0.040	—	—

[a] Applies to round cold finished tubing. Wall thickness tolerance is 10% except 15% for 1/16 to 1/8 in. dia.
[b] O.d. tolerances for hot finished tubing: ±0.023 for dia up to 3 1/2 in.; ±0.031 for 3 to 5 1/2 in.; ±0.047 for 5 1/2 to 10 3/4 in. Wall thickness tolerances for hot finished tubing: ±16.5% for wall thickness less than 0.109 in.; ±15% for 0.110 to 0.172 in.; ±14% for 0.173 to 0.203 in.; 12.5% for thicker walls.
[c] Below 8 in., ranges are not inclusive of higher figure.
[d] For tubes which cannot be successfully drawn over a mandrel [often true of those with: 1) i.d. <50% of o.d., 2) wall >25% of o.d., 3) wall >1 1/4 in. thk, 4) weight >90 lb per ft], i.d. tolerance is ±10% of the wall thickness and wall thickness tolerance is 12%.
[e] For certain other tubes which are not commonly drawn over a mandrel (specifically, those with i.d. <1/2 in., or with i.d. <5/8 in. when wall thickness >20% of o.d.), the wall thickness tolerance is 15% and the i.d. is governed by the standard tolerances for o.d. and wall thickness.
[f] Tubes with wall <3% of o.d. cannot be straightened properly without distortion and require an additional ovality tolerance of ±1/2% for the o.d. and i.d.
[g] When wall <5% of o.d. [h] When 5% of o.d. <wall <7.5% of o.d. When wall >7.5% of o.d.

TOLERANCES FOR STAINLESS STEEL TUBING[a]

Diameter, in.[b]	Diameter Tolerances[c]			Wall Thk, in.	Wall Thk Tol for Welded Tubing, in.[d,e]
	Seamless O.D. Tol, in.	Welded			
		O.D. Tol, in.	I.D. Tol, in.		
Up to 3/32	0.005	0.001	0.001	0.025	0.002-0.003
3/32 to 3/16	0.005	0.0015	0.0015	0.032	0.003-0.004
3/16 to 1/2	0.005	0.003	0.005	0.035	0.003-0.005
1/2 to 1	0.005	0.004	0.006	0.042	0.003-0.005
1 to 1 1/2	0.005	0.005	0.007	0.049	0.003-0.005
1 1/2 to 2	0.010	0.006	0.008	0.058	0.004-0.006
2 to 2 1/2	0.010	0.007	0.010	0.065	0.005-0.006
2 1/2 to 3 1/2	0.010	0.010	0.014	0.072	0.005-0.007
3 1/2 to 5	0.015	0.015	0.020	0.083	0.005-0.007
3 1/2 to 5 1/2	0.015	—	—	0.095	0.005-0.007
5 1/2 to 8	0.030	—	—	0.109	0.005-0.007
8 to 8 5/8	0.045	—	—	0.120	0.005-0.007
				0.134 and over	0.007-0.008

[a] Round tubing; annealed or as cold finished. All values are ±. [b] Ranges are not inclusive of upper values.
[c] Tolerances are general and subject to limitations by D/t ratio. Ovality tolerance is generally double the o.d. tolerance.
[d] Tolerance for seamless is ±10%; 15% when o.d. <1/2 in. [e] Ranges are given because tolerance varies with o.d.

TOLERANCES FOR NICKEL AND NICKEL ALLOY SEAMLESS TUBING*

Dia, in.	Dia Tol, in.[b,c]	Wall Thk Tol, %[b]
Monel, A Nickel, Low Carbon Nickel		
Up to 3/8	+0.005	12.5
3/8 to 1 1/2	0.005	10
1 1/2 to 4 1/2	0.010	10
4 1/2 to 6	0.015	12.5
6 to 7 1/2	0.020	12.5
7 1/2 to 8 3/8	0.025	12.5
Inconel, Inconel X, K Monel, Incoloy		
Up to 3/8	0.005	15
3/8 to 1 1/2	0.0075	10
1 1/2 to 3 1/2	0.010	10
3 1/2 to 4 1/2	0.015	10
4 1/2 to 6	0.020	12.5
6 to 6 3/8	0.025	12.5

* Round cold drawn. All tolerances ± except where otherwise indicated. Tolerances given here are applicable only to two dimensions at a time. Diameter ranges are not inclusive of lower values.
[b] The following applies only to tubes which cannot be successfully drawn over a mandrel: 1) If i.d. < 50% of o.d., the i.d. tolerance is ±10% of the wall thickness and the wall thickness tolerance is 12½% for alloys in top part of table, 15% for others; 2) if i.d. < ½ in., the i.d. will be governed by standard tolerances for o.d. and wall thickness.
* Tubes with wall < 3% of o.d. cannot be straightened properly without distortion and require an additional ovality tolerance of ±½% for the o.d. and i.d. Tubes furnished in soft annealed temper may possess ovality because of warpage during annealing or straightening and will not have tolerances as close as table indicates.

TOLERANCES FOR SMALL DIAMETER TUBING*

Dia, in.[b]	O.D. Tol, in.	I.D. Tol, in.
Up to 1/32	+0.002	−0.002
1/32 to 1/16	+0.003	−0.003
1/16 to 1/2	+0.004	−0.004
1/2 to 1 1/2	+0.005	−0.005

* Wall thickness tolerance is ±10%. These tolerances are general; suppliers specializing in particular materials or sizes often hold closer tolerances for standard tubing.
[b] Range is not inclusive of higher value.

TOLERANCES FOR COPPER AND COPPER ALLOY SEAMLESS TUBE*

Dia, in.[d]	Mean Diameter Tolerances, in.[b]		Wall Thickness, in.*	Wall Thickness Tolerances, in.[c]	
	Nonrefractory	Refractory		Nonrefractory	Refractory
Up to 1/8	0.002	0.0025[f]	Up to 0.018	0.001 –0.002	0.0015–0.0025
1/8 to 3/8	0.002	0.0025	0.018 to 0.025	0.002 –0.003	0.0025–0.004
3/8 to 1	0.0025	0.003	0.025 to 0.035	0.0025–0.004	0.003 –0.005
1 to 2	0.003	0.004	0.035 to 0.058	0.003 –0.007	0.004 –0.009
2 to 3	0.004	0.005	0.058 to 0.083	0.0035–0.010	0.0045–0.013
3 to 4	0.005	0.006	0.083 to 0.120	0.004 –0.011	0.005 –0.014
4 to 5	0.006	0.008	0.120 to 0.165	0.005 –0.012	0.007 –0.015
5 to 6	0.007	0.009	0.165 to 0.220	0.007 –0.014	0.009 –0.018
6 to 8	0.008	0.010	0.220 to 0.284	0.009 –0.016	0.012 –0.020
8 to 10	0.010	0.013	0.284 to 0.380	0.011 –0.018	0.015 –0.023
			0.380 and over	5–6%	6–8%

* Round tubing. All values are ±.
[b] Tolerances apply to i.d. or o.d. except where otherwise indicated.
[c] Maximum deviation at any point; range indicates variation with o.d.
[d] Ranges are not inclusive of lower values. * Ranges are not inclusive of upper values.
[f] O.d. only; value for i.d. is 0.003 in.

TOLERANCES FOR EXTRUDED AND DRAWN ALUMINUM TUBING*

Diameter, in.[b]	Diameter Tol, in.		Wall Thk, in.	Wall Thk Tol, in.*	
	Drawn	Extruded		Drawn	Extruded
Up to 1/2	0.003	—	Up to 0.047	—	0.006
1/2 to 1	0.004	0.010	0.010 to 0.035	0.002	—
1 to 2	0.005	0.012	0.036 to 0.049	0.003	—
2 to 3	0.006	0.015	0.047 to 0.061	—	0.007–0.010
3 to 4	0.008	0.015	0.062 to 0.077	—	0.008–0.012
4 to 5	0.008	0.025	0.050 to 0.083	0.004	—
5 to 6	0.010	0.025	0.078 to 0.124	—	0.009–0.015
6 to 8	0.015	0.035	0.084 to 0.120	0.005	—
8 to 10	0.020	0.045	0.121 to 0.203	0.006	—
10 to 12	0.025	0.055	0.125 to 0.249	—	0.009–0.020
12 to 12.875	—	0.065	0.204 to 0.300	0.008	—
			0.250 to 0.374	—	0.011–0.025
			0.301 to 0.375	0.015	—
			0.375 to 0.499	—	0.015–0.035
			0.376 to 0.500	0.020	—
			0.500 to 2.000	—	0.020–0.075

* Round tubing. All values are ±.
[b] Range is inclusive of upper value for drawn tubing, lower for extruded.
[c] Allowable deviation of mean from specified wall thickness.

TOLERANCES FOR EXTRUDED MAGNESIUM TUBING*

Dia, in.[b]	Mean Dia Tol, in.	Wall Thickness, in[b]	Mean Wall Thk Tolerance, in.		
			O.D. to 2.99	O.D. 3.00–4.99	O.D >5.00
Up to 1/2	0.008	Up to 0.062	0.007	0.008	0.010
1/2 to 1	0.010	0.063 to 0.124	0.008	0.010	0.015
1 to 2	0.012	0.125 to 0.249	0.009	0.013	0.020
2 to 4	0.015	0.250 to 0.374	0.011	0.016	0.025
4 to 6	0.025	0.375 to 0.499	0.015	0.021	0.035
6 to 8	0.035	0.500 to 0.749	0.020	0.028	0.045
8 to 10	0.045	0.750 to 0.999	—	0.035	0.055
10 to 12	0.055	1.000 to 1.499	—	0.045	0.065

* Round. All values are ±. [b] Ranges are not inclusive of higher values.

Wire Parts, Forms and Assemblies

Advantages. Wire forms, ranging from simple bent or ended wire to welded wire assemblies, are used in original design as well as to replace stampings, castings and forgings. In addition to the extreme design adaptability, wire forms offer economy, resiliency, lightness and decoration.

Materials. Although basic steel wire is used for the majority of wire forms, any material which can be drawn into wire may be used. Special types of steel wire include: galvanized (rust protection), Bethanized (rust and corrosion protection), coppered or tinned (attractive finish at low cost), spring wire (added stiffness and tensile strength), stainless steel (electropolished), and Copperweld, Nickelply and Copperply for special applications. Standard nonferrous metals include: monel, copper, bronze, brass and nickel silver. Special metals used are: aluminum, tungsten and molybdenum.

Sizes. Wire diameters from 0.035 in. (20 gage) to 0.375 in. (⅜ in.) are usually suitable for most wire form designs. Sizes as large as 0.5 in. or as small as 0.0015 in. are sometimes required. Etched wire is produced in sizes down to 0.00012 in.

Finishes. Wire products may be finished by electroplating, enameling or lacquering. The most popular plated finishes are: nickel, chromium, brass, cadmium and zinc. Special finishes include: anodized aluminum, plastics coating, and a black oxidized finish applied over zinc plate.

Parts and Forms. In addition to the parts and forms discussed below, drawings on this page illustrate standard wire end treatments.

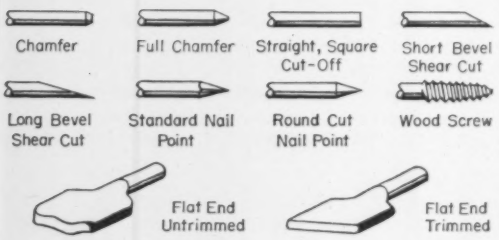
Eyes and ears—Eyes are formed in plain or teardrop shapes by plain or centered bends. Ears may be formed on one or both sides.

Upset pins—Standard pins are produced from wire of 0.010 to 0.125 in. dia, of any workable alloy and in various head shapes. If both a flange and head, or two or more flanges, are required, at least 0.070 in. spacing between adjacent faces is desirable.

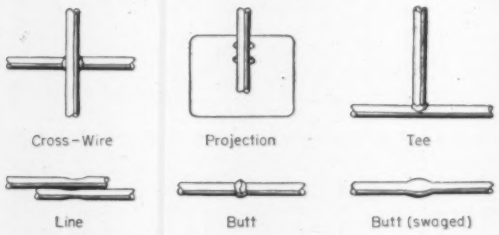
Wire threadings—Threads can be rolled or cut. Rolled thread has these advantages: less expensive; faster forming; no special fixtures; smaller dia wire required; chamfered end not necessary for easy starting. Cut thread has these advantages: stock size larger (or equal to) o.d. of thread; thread length not limited; can have chamfered end.

Formed rings—Rings may be formed on a wire ring coiler or a four-slide machine. Those formed on the slide machine do not butt perfectly; they are made from wire of 1/16 to 5/16-in. dia and in ring diameters of 1/2 to 2-in. i.d. Both flat and offset rings may be formed on the wire coiler. Wire diameter ranges from 1/16 to 5/16 in. and ring diameter from 5/8 to 3-in. o.d. Spiral rings are generally offset about one wire thickness.

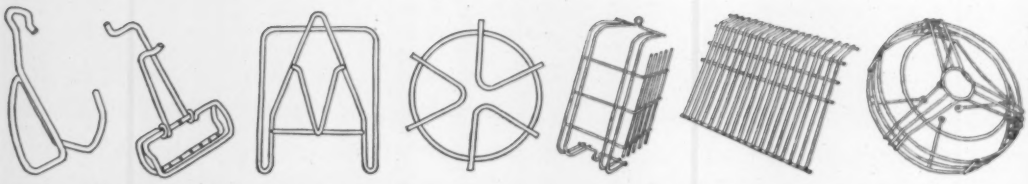
Welded wire assemblies. For attaching wire together, or wire to strip, the most efficient operation is resistance spot welding. It is preferable that welds occur where two wires cross each other at right angles.



Wire end treatments



Welded wire joints



Typical wire forms and welded assemblies

Plastics Parts

The form in which plastics materials should be specified is largely determined by the nature of the material. Plastics resins are either thermoplastic or thermosetting in nature. Thermoplastic resins soften and flow when heated and harden when cooled. For moldings, the polymer is usually supplied in granular form. After being heated to the fluid state it is charged to the mold or die, where it cools and hardens.

Thermosetting plastics do not soften when heated, but gradually lose properties as temperature increases, until they char and disintegrate. For moldings, thermosetting resins are usually supplied in a partially polymerized granular form, usually with some type of fibrous reinforcement. They flow to a limited degree on initial heating, but as heating continues they polymerize completely and cure to a hard infusible state.

Molded Parts

Injection molded parts. The injection molding process for plastics is similar in nature to the die casting process for metals. A thermoplastic molding compound is heated to plasticity in a cylinder at a controlled temperature and forced under a pressure of 10,000 to 50,000 psi through sprue, runners and gates into a cool single or multiple cavity mold. The resin solidifies rapidly, the mold is opened, and the part or parts ejected.

The primary advantage of the process, as is the case with die castings, is the relatively low cost per part. Multiple cavity molds can often be used. The cycle is rapid, since parts can be removed from the mold as soon as they solidify sufficiently.

In some cases modifications of the injection molding process can be used to mold small parts of thermosetting resins. These processes are called jet, flow or offset injection molding. They make use of the fluid state of thermosetting molding materials before complete polymerization. The process is suitable only for relatively small parts, and is one that requires careful control of processing variables, such as temperature.

Compression molded parts. Compression molding is primarily used to mold thermosetting plastics, though in some instances it can be used economically to mold thermoplastics, e. g., vinyl phonograph records. Thermoplastic materials cannot usually be preformed, but are charged as powder or granules.

In compression molding, a partially polymerized thermosetting resin, usually in the form of a preform made from powder or granules, is placed in the heated mold cavity. The mold is closed, heat and pressure are applied, and the material flows and fills the mold cavity. The heat then fully polymerizes the material before the mold is opened and the part removed.

In the case of thermoplastic materials, heating softens the polymer, which flows and fills the mold. Then the mold is cooled and the part solidifies.

Less material is required for compression molding than for injection or transfer molding, since the material is placed directly in the mold, and no sprues, runners or gates are required. With thermosetting resins, the cycle is longer than in injection molding, since the part must be cured in the mold.

Cold molded parts. Cold molding is similar to compression molding in that it makes use of a split, or open, mold in which the material is charged. It differs from compression molding in that it uses no heat—only pressure on the order of 2000 to 12,000 psi. After the part is removed from the mold it is placed in an oven to cure to its final state.

Materials used for cold molding are classified as nonrefractory (organic) and refractory (inorganic). Organic types consist of binders — such as asphalts, oil derivatives and residues, and gum or resin solutions — and fillers, such as asbestos fibers and silica and magnesia compounds. Inorganic types consist of binders — such as cement, lime or silica — and fillers, such as asbestos.

Cold molded parts are primarily used for electrical components. The materials have excellent electrical insulating properties, as well as resistance to moisture and heat.

Transfer molded parts. Transfer molding of thermosetting materials is roughly analogous to injection molding of thermoplastics. The thermosetting molding compound is heated to plasticity in a transfer chamber, and is then fed to the mold cavity (or cavities) through sprue, runners and gates. After the mold is filled, heat is maintained for a predetermined period of time to fully polymerize and cure the part.

In comparison with compression molding, transfer molding is particularly advantageous where thin sections or delicate inserts are used. Since the design of runners and gates permits some control over where the material is to be fed to the mold, flow of the material can be more closely controlled than in compression molding. Also, closer tolerances can usually be held on transfer molded parts. On the other hand, transfer molds are usually more elaborate than compression molds, and there is a loss of material in the cull and sprue. Size of transfer molded parts is somewhat limited.

Design factors. Though it is difficult to generalize about design factors for injection, compression and transfer moldings, the following factors should be considered:

Shrinkage—Allowance must be made for shrinkage of the molding compound in design of the part. In addition to affecting dimensional accuracy of the part, shrinkage can introduce internal stress which may make the part unserviceable. Shrinkage values for the various plastics are given in the data sheets in Section 5 of this issue.

Wall thickness—Strength required both in service and during manufacture must be considered in designing wall thickness. In thermosetting materials, walls less than 0.062 in. thick are extremely difficult to obtain, and a minimum of 0.125 in. is preferred (see accompanying table).

Draft—A draft taper in deep drawn parts, in addition to making it easier to remove a part from the mold, creates a wedging action as the the mold is closed. When thermosetting materials are compression molded, converging tapers increase the density of the plastic in the upper sections. There are no precise formulas for taper, but the most liberal taper the design can allow should be provided. Tapers of less than 1 deg can be used for deep parts; e.g., television cabinets 6 to 24 in. deep have been molded with tapers as small as 0.001 in. per in.

Tolerances—A high degree of accuracy in molded parts is expensive to achieve. On small shapes, tolerances as close as ±0.002 in. are possible. When

Plastics Parts

size is increased to a few inches, over-all tolerances increase to approximately ±0.005 in. On large pieces, tolerances of about ±0.001 to 0.002 in. per in. are obtainable. Tolerances closer than actually mandatory should not be specified; as specified accuracy increases, cost increases disproportionately.

Design Rules.

1. Use sufficient draft on long thin shapes to permit their withdrawal from the mold.

2. Minimize coring. When cores are used they should be easy to withdraw.

3. Avoid internal and external undercuts; they make withdrawal of parts difficult and require considerably more expensive molds.

4. Provide ample fillets on inside corners, and avoid sharp external edges and corners except at the parting line of the die.

5. Avoid large flat areas. Dappling or otherwise breaking up the surface is recommended.

6. Keep tolerances as liberal as possible. Excessively close tolerances add to cost because of increased die costs and high rejection rate.

7. Avoid abrupt changes in wall thickness.

8. Locate parting lines so that flash can be removed easily without marring surrounding areas.

9. Locate holes for easy coring.

10. Use ribs to achieve desired strength and stiffness. Ribs permit materials savings by reducing section thickness.

11. Use inserts for threaded holes where high stresses are anticipated or where considerable wear is to be encountered. Round inserts are preferred.

WALL THICKNESS OF MOLDED PARTS (In.)

Material ↓	Minimum	Small Parts	Average	Large Parts
THERMOSETTING				
Phenolics				
General Purpose & Flock-Filled	0.050	0.062	0.125	0.187–1.000
Fabric-Filled	0.062	0.125	0.187	0.187–0.375
Mineral-Filled	0.125	0.125	0.187	0.200–1.000
Alkyd				
Glass-Filled	0.040	0.093	0.125	0.187–0.500
Mineral-Filled	0.040	0.125	0.187	0.187–0.375
Ureas, Melamines				
Cellulose-Filled	0.035	0.062	0.100	0.125–0.187
Fabric-Filled	0.050	0.125	0.125	0.125–0.187
Mineral-Filled	0.040	0.093	0.187	0.187–0.375
THERMOPLASTIC				
Acrylics	0.025	0.035	0.093	0.125–0.250
Cellulose Acetate	0.025	0.050	0.075	0.125–0.187
Cellulose Acetate Butyrate	0.025	0.050	0.075	0.125–0.187
Ethyl Cellulose	0.035	0.050	0.062	0.093–0.125
Polyamide	0.015	0.025	0.060	0.093–0.125
Polyethylene	0.035	0.050	0.062	0.093–0.125
Polystyrene	0.030	0.050	0.062	0.125–0.250
Polyvinyl Chloride	0.093	0.062	0.093	0.125–0.250

Castings

Materials. Any resin available in liquid form can be cast. Castable resins include phenolics, polyesters, epoxies, silicones and acrylics.

Types of molds. The type of mold used depends on the plastic, the size and shape of the part, and other design considerations.

Draw mold—No undercut is possible. Flutes and scallops must run in the direction of removal. Taper must be provided to break the vacuum and reduce friction. Castings are removed by force, and minimum wall thickness is critical, running from 1/8 in. on tiny parts to 3/16 in. on parts the size of radio cabinets.

Split mold—Undercuts may be provided if they do not prevent release from the separate parts of the mold. Minimum wall thickness is 3/16 in., and parts less than 0.1 lb are not commonly produced economically.

Cored mold—This type allows complexity of design, but is not usually feasible from a cost standpoint for parts less than 4 x 4 x 4 in. Molds require no taper. Minimum wall thickness is 3/16 in. Mold shrinkage allowance must be considered. Extremely large parts may be cast.

Flexible mold—Model may be constructed of wood, porcelain, metal, etc. Mold is of plaster with a lining of rubber latex or an elastomeric plastic. Epoxy materials may be cast in flexible molds, but most polyesters react with the lining material. Although parts cast in rubber molds cannot be held to the tolerances possible with matched metal molds, a reasonable degree of accuracy is reproducible. For example, on cast phenolic parts dimensions can be held to about ±0.004 in. per in. The degree of accuracy obtainable on any part depends on the oversize allowance used in making the master pattern, the care with which the pattern is made, and the degree of accuracy attained in calculating amount of shrinkage during cure of the rubber mold and the cast resin.

Extrusions

In many cases, extruded parts are competitive with molded parts. Where many parts are required with a complicated cross section in one plane, the cross section can be produced by extrusion, and the parts formed by rapid, automatic cut-off to shape.

Thermoplastics. In extruding a thermoplastic, the molding powder is fed through a hopper to a chamber in which it is heated to plasticity at a controlled temperature. The plastic powder is then driven, usually by a rotating screw, through a die having the shape of the desired cross section. The process is continuous and is used to produce tube, rod, film and sheet, as well as other continuous shapes.

Thermosets. Reinforced thermosetting tube and rod can be produced by an extrusion process. The reinforcing fibers are fed continuously through a bath of liquid thermosetting resin and then through a die of the desired cross section. The extruded shapes then pass through a cylinder held at a controlled temperature to polymerize and cure the thermosetting resin. Extrusion speed must be relatively slow to provide sufficient time for complete cure.

Thermoplastic Sheet Formed Parts

Materials. A variety of shapes and forms can be produced by thermoforming calendered, cast or extruded thermoplastic sheet. The materials that lend themselves to this method of forming include polystyrene and modified polystyrenes, acrylics, cellulose acetate and cellulose acetate butyrate, vinyl polymers and copolymers, and polyethylene. Use of this type of molding has grown with the development of relatively low cost extruded sheet to replace more expensive cast or calendered materials.

Methods. Essentially, thermoforming involves preheating the flat sheet to 180 to 360 F, the temperature depending on the material, and then forming by mechanical, air or hydraulic pressure to the desired shape. After cooling, the part is taken from the mold, and unwanted flanges are sawed or blanked from the part. All of the different processes have in common low forming pressures, and thus low cost molds and equipment (see box on next page for details on the types of parts producible by each method). In recent years, rapid-cycle forming machines have been developed to make sheet molding more practical for large production quantities.

Reinforced Plastics Moldings

The term "reinforced plastics moldings," as used here and in the plastics industry, refers to parts produced by impregnating a reinforcing material, in the form of cloth or mat, with a liquid thermosetting or thermoplastic resin, laminating the material into multiple layers, and curing with heat and pressure to form a dense, hard solid. It does not include materials discussed later as "high pressure laminates," which are available from stock as flat sheet, rod or tube.

Materials. Resins used for reinforced plastics moldings include polyesters, phenolics, epoxies, melamines and silicones. Reinforcements include cloth or mat made from cotton, glass, asbestos and nylon. Glass reinforcements are most commonly used. Recently, there has been much interest in reinforcing thermoplastic resins, such as vinyls and acrylics, with cloth or mat made from thermoplastic synthetic fibers such as nylon. However, the bulk of reinforced plastics moldings today utilizes thermosetting resins.

Methods.

Contact molding—A low cost mold is used. Layers of reinforcing material are placed by hand against the mold surface; and resin is added, either by spraying or brushing after each layer is located. After sufficient layers of mat or cloth have been saturated with resin, they are allowed to harden without external application of heat and without applied pressure.

Vacuum bag molding—Procedure is similar to contact molding except that when lay-up is completed, a flexible sheeting, usually polyvinyl alcohol, is placed over the impregnated reinforcement and a vacuum is drawn between the sheeting and the mold surface. This provides about 12 psi pressure on the part, permitting higher glass content.

Pressure bag molding—Similar to vacuum bag molding except that a tailored bag is placed against the sheeting, and pressure is applied inside the bag to expand it against the impregnated reinforcement (sometimes pressure is applied directly on the sheeting). Pressures up to 50 psi are usually used, making high glass contents practical. Sometimes the entire assembly is placed in a large autoclave that contains hot air or steam at 50 to 100 psi pressure ("autoclave molding").

Flexible plunger molding—A metal female mold is usually employed and glass and resin are placed in the heated cavity. The plug portion is made of medium hard rubber, and is the approximate shape of the part to be molded. The rubber plug provides uniform, high and fluid pressure. High glass contents are possible. This method is not practical for large moldings because of the high pressures and the limitations of the flexible plunger.

Vacuum injection molding—Two molds, often made of glass-reinforced plastics, are used. The reinforcement is laid between the two molds and the resin is poured in a moat around the bottom. The resin is then sucked by vacuum up through the reinforcement. This tends to give air-free parts, and is used primarily for large parts. Glass contents are usually low.

Matched die molding—Can be used for parts up to about 60 sq ft in area, and is generally used for high production runs. Uses two metal molds which have a close-fitting, telescoping area to seal in the resin and trim the reinforcement. The molds are heated (with steam or electricity) to about 240 F. Where the length of run is sufficient, this method gives the lowest cost moldings and the highest production rates.

Design rules. Designing molded reinforced plastics parts is difficult because of the large number of variables encountered in the material and the process, and the difficulty of controlling some of them. These variables include: 1) composition of the resin, including fillers, catalysts and hardening agents, 2) geometry of the reinforcing material, 3) resin-reinforcement ratio, 4) degree of saturation of reinforcement by resin, and 5) temperature and time of cure.

The cardinal design rule, which cannot be overemphasized, is: consult the custom molder in the primary design stages. In addition, follow these general design rules:

1. Integrate parts.
2. Make prototypes.
3. Mold to dimensions; parts cannot be "sprung" after they are molded.
4. Use stress formulas valid for fiber-reinforced plastics.
5. Know the conditions of use.
6. Consider effects of the molding procedure.
7. Use sandwich construction for maximum strength-to-weight ratios.
8. To increase rigidity in stressed areas: a) increase the glass loading, b) use unidirectional reinforcement where practical, c) place flanges and lips on edges, d) use ribs, corrugations, beads and dimples, e) increase wall thickness. f) use curved sections rather than flat areas where possible, and g) use sandwich construction.
9. Avoid drastic changes in wall thickness.
10. Avoid sharp corners; use liberal radii.
11. Use maximum draft.
12. Avoid undercuts.

continued on next page

Plastics Parts

Thermoplastic Sheet Forming Methods

Cold bending. Simple circular or cylindrical shapes. The thicker the sheet, the larger the bend diameter must be to prevent high stress concentrations. Ex: consumer packages.

Hot line bending. Two-dimensional shapes with arc, angle or channel cross section. Gradual to sharp bends, depending on heating procedure. Ex: safety guards.

Stretch forming (hot draping, yoke forming). Two-dimensional or slightly compound shapes, especially large shapes. Subject to surface distortion. Not suitable for reproduction of fine details. Yoke forming provides more uniform thinning out and is suitable for longer runs than manual stretch forming. Ex: aircraft canopies.

Plug and ring forming. Shallow to deep drawn shapes with gradual to sharp angles and curves. Not suitable for highly accurate contours or fine mold details. Considerable surface distortion, especially at inside corners — unsuitable where optical properties are critical. Ex: trays.

Slip forming. Same as yoke forming or plug and ring forming except that much more uniform thickness and less optical or pattern distortion can be obtained throughout the part, especially in deep drawn shapes. Fluted edges obtained by increasing clearance. Ex: carrying cases.

Free blowing or free vacuum forming. Somewhat modified surface tension shapes (tending toward fishbowl shapes) determined by shape or clamping ring and depth of draw. Internal flanges. Tolerances ¼-½ in. Good optical properties. Vacuum method easier to control and preferred where 15 psi is sufficient pressure. Ex: aircraft domes.

Ridge forming. Simple or complex (with vacuum and/or air pressure) shapes with minimum surface distortion and low mold cost. Generous radii necessary to avoid tearing at ridges during forming. Combines possibilities of plug and ring forming, free blowing or free vacuum forming, vacuum forming and vacuum snapback forming. Ex: equipment housings.

Vacuum forming or blow molding in female mold. Usually limited to relatively shallow draws, and relatively large angles and radii—more so the thicker the sheet. Blow molding offers higher pressures and is therefore more suitable for smaller angles and radii, especially in thicker sheet; also reduces forming temperature required for thick sheet. Both produce some surface distortion—less so the more the shape of the mold resembles a surface tension shape. Ex: display signs.

Blow-dieing. Small, thin shapes having greatest perimeter larger than neck — especially closed spherical or modified spherical shapes. Not suitable for close tolerances. Ex: hollow toys.

Vacuum forming over male plug (drape forming). Shallow to deep drawn shapes with relatively sharp angles and curves can be made with good accuracy and reproduction of fine mold detail, and without excessive thinning out. More accurate than plug and ring forming but not as suitable for thick sheet. Subject to surface distortion, especially at bottom of draw. Ex: display signs.

Vacuum snapback forming. Especially suitable for modified surface tension shapes with minimum mark-off and closer tolerances (⅛ in.) than obtainable in free blowing or free vacuum forming. Simple snapback method not suitable for reverse curves or sudden contour changes, but more complex shapes and finer reproduction of mold detail are provided by additional vacuum or air pressure. Integral flanges. Combines possibilities of free vacuum forming and plug and ring forming. Ex: aircraft domes.

Matched die molding (embossing). Especially suitable for shallow draws, long runs and embossed surfaces. Relatively uniform thickness, good mechanical properties. Subject to surface distortion on both sides. Ex: watch crystals.

Die pressing. Small, simple shapes that can be approximated in precut blank and have somewhat varying thickness, or relatively great thickness compared to over-all size. Ex: brush backs.

13. Consider use of molded-in holes.
14. Consider mold shrinkage.
15. Design to practical dimensional tolerances.
16. Design to avoid warpage.

Secondary fabrication. See "High Pressure Laminates" below.

High Pressure Laminates

The term "laminates" used here refers to those reinforced plastics materials formed by high pressures (over 1000 psi). Vulcanized fibre is also included because of the similarity of its applications. These materials are available as sheet, rod or tube.

Materials. Resins used include phenolics, melamines, silicones and epoxies, and reinforcements consist of

MINIMUM COLD BENDING RADII FOR RIGID VINYL SHEETS

Calendered		Planished	
Thickness, in.	Min Bend Rad., in.	Thickness, in.	Min Bend Rad., in.
0.005 -			
Long.	½	0.010	12
Trans.	2	0.020	12
0.010		0.030	14
Long.	1	0.040	14
Trans.	6½	0.050	18
0.015			
Long.	3		
Trans.	9		

cellulose paper, asbestos paper, or fabric or mat made from cotton, glass, asbestos or nylon fibers. Vulcanized fibre has only one component—cellulose. It is made by laminating chemically gelled paper, leaching out the chemical, and calendering. The resulting laminate is tough and hornlike, and has good electrical properties. Properties of standard NEMA (National Electrical Manufacturers' Assn.) laminates are given in Section 5 of this issue.

Postforming. Certain grades of laminates can be postformed by the use of heat and pressure. Temperatures, times and pressures vary with grade of laminate, thickness of material, and design. Temperatures generally range between 350 and 480 F, heating time usually ranges from a few seconds to a few minutes at most, and pressures range from a few pounds to several hundred pounds per square inch.

Although the following formability values should not be used for design, they do indicate general limits for postforming. Minimum radii are measured on the inside of bends, and apply to bends made lengthwise and crosswise. Smaller radii can be achieved with cloth-base laminates by orienting the sheet so that bends are made diagonally to the warp and fill directions.

Thickness, in.	Min Bend Rad., in.
1/32	1/32
1/16	3/32
3/32	3/16
1/8	5/16
3/16	9/16
1/4	1
5/16	1 3/4
3/8	2 1/2

Postforming grade laminates can be drawn to moderate depths. Both paper and cloth-base laminates in 1/16-in. thickness can be drawn to a depth of about 1¼ in. in a 3-in. dia spherical cup.

Vulcanized fibre can be formed by the use of moisture and pressure. Water softens or plasticizes the fibre to the extent that it can be formed under relatively low pressures, usually between 200 and 500 psi. In addition to forming in matched die presses, vulcanized fibre can be formed in standard sheet metal angle brakes and in punch presses if the design is simple and only a little moisture is required.

Secondary fabrication. Machining and other secondary operations carried out on reinforced plastics are similar for both low and high pressure moldings, as well as for laminates.

Blanking and punching—Use of a punch press with a hard, well-made blanking or punching die is the accepted production method for cutting flat stock, putting holes into side walls of moldings, and other piercing steps. Punching of reinforced plastics results in holes that are 0.002 to 0.010 in. smaller than the punch. Blanking gives parts 0.001 to 0.005 in. larger than the die. In each case, these values depend on a relation based on the thickness and the proportion of reinforcement. This "shrinkage" causes the material to seize the dies, so that a strongly loaded spring stripper mechanism is desirable. It has been estimated that a pressure of 20,000 psi (on the shear-edge area) is sufficient for blanking, punching and shearing.

Shearing—Shearing of ½-in. thick stock is quite feasible. For best results, the piece should have a width of at least twice the thickness of the parent stock. Shear gibs must be snug and blades sharp.

Sawing—Abrasive cutting wheels should be used whenever possible; rigid mounting of both the wheel and the work is important. A metal cutting blade, if used, should have coarse, offset, wide-spaced teeth.

Drilling—Accurately located holes on side walls are difficult to mold. Where small runs are made, and where precision is required, drilling is recommended. There is no limit to the thickness that can be drilled.

Tapping—Tapping is seldom performed, because the strength of a screw and tapped hole system is inferior to that of a nut and bolt assembly. Where light duty connecting is called for, self-tapping screws are satisfactory.

Grinding—Widely used to provide the taper in glass fiber-reinforced plastics fishing rods. Satisfactory automatic machines are in common use. Standard coolants are employed so that rapid feeds and minimized wheel loading are possible.

Routing, milling, turning—Routing is a practical production edging process and is faster and more accurate than jig-sawing where moderate numbers of irregular holes are to be cut. Milling and turning are not frequently required, but can be readily accomplished. Well-sharpened carbide or diamond-tipped tools provide good efficiency; speeds and feeds appropriate for brass are recommended.

DESIGN FACTORS FOR GLASS-REINFORCED PLASTICS MOLDINGS•

Type of Molding →	Bag	Flexible Plunger	Vacuum Injection	Matched Die
Inside Radius (min), in.	½	½	½	⅛
Molded-In Holes	Large only	No	No	Yes
Trimmed in Mold	No	No	No	Yes
Built-In Cores	Yes	Not rec	Yes	Not rec
Undercuts	Yes	Only slight	Not rec	No
Draft (min), deg	5	1	3	1
Thickness (min), in.	1/10	1/16	1/10	1/32
Practical Thickness (max), in.	1	¼	½	¼
Normal Thickness Variation, in.	±0.020	±0.015	±0.020	±0.008
Thickness Build-Up (max)	As desired	2 to 1 max	As desired	2 to 1 max
Corrugated Sections	Core better	Yes, 1-in. rad.	Yes	Yes
Metal Inserts	Yes	Not rec	Yes	Possible
Surfacing Mat	No	Yes	Not rec	Yes
Size of Part (max), sq ft	2000	100	1000	175
Metal Edge Stiffening	Not rec	Not rec	Not rec	Yes
Bosses	Possible	Possible	Possible	Possible
Fins	Yes	No	No	Short, yes
Molded-In Labels	Yes	Yes	Not rec	Yes
Raised Numbers or Letters	Yes	Yes	Yes	Yes

•Not rec=not recommended at present time.

Rubber Parts

General

Although there are many similarities between rubber and plastics materials and forming methods, there are several important differences.

For one thing, the form in which *plastics* materials are specified is almost entirely determined by the nature of the material: the thermoplastic resins soften and flow under heat and pressure; the thermosetting plastics do not. *Rubber* materials, or elastomers, are very similar to thermoplastics when first placed in the mold, i.e., they soften when heated and flow under pressure. However, upon further heating, vulcanization, or crosslinking, occurs and the materials become roughly equivalent to thermosetting plastics. As a result, forming methods used for rubbers are generally similar to those used for thermosetting plastics and are specified not on the basis of materials used but on the basis of economics, shape of the part, and precision required.

Another major difference between plastics and rubber materials is the way in which rubber molding compounds are specified. Although there are many standard rubber compounds, most rubber parts are specified by performance characteristics rather than by specific materials. Each rubber material not only has its own special characteristics, but is capable of being modified to meet a wide variety of specific end service requirements.

A typical rubber compound contains, in addition to the base polymer, two types of ingredients: those that serve the general functions of vulcanizing and stabilizing the polymer, and those that serve special purposes such as reinforcement, bulking, stiffening, softening, coloring or reodorizing.

When specifying rubber parts, therefore, the designer should work very closely with the compounder and/or molder (often the same) and request a compound that: 1) provides the required service properties; 2) is capable of being processed with a minimum of waste and rejects; and 3) minimizes material, labor and power costs.

Rubber materials can be compounded to meet most requirements of hardness; tensile and compression properties; low temperature properties; tear, abrasion and impact resistance; resilience; adhesion; chemical and oil resistance; aging and weather resistance; and processability. However, extreme values cannot be obtained in one property without detracting from others, and some properties can be obtained only at the expense of others.

Molded Parts

Compression molded parts. Most molded rubber parts are made by compression molding. In this process, an excess amount of uncured rubber compound is placed in the mold cavity so that a flash is formed between the mold plates. For simply shaped thin parts, the mold may consist of only a base plate (containing one or more cavities) and a cover plate. For deeper or more intricate shapes, it is necessary to design a mold consisting of three or more pieces.

Cores and inserts can be used to form holes and inner recesses. Close tolerances can be held on all dimensions except across the mold parting line. Parts are uniform, with good finish, and can be made in almost any hardness, color, shape or size. In comparison with other types of molding, compression molds are relatively cheap and can be operated with relatively low labor cost.

Transfer molded parts. In transfer molding, rather than loading the mold by placing stock directly in the mold cavities, the mold is closed empty and the rubber is forced into it through sprues, runners and gates. Advantages of transfer molding as compared to compression molding are: 1) minimized thickness variations in finished parts, resulting in closer tolerances; 2) practically no flash; 3) the ability to produce intricate parts not practical by compression molding; and 4) good finish.

Mold and press overhead costs, on the other hand, are generally higher (up to 50%); but labor costs are usually less. Not all compounds will flow suitably for this method. And although flash is minimized, sprue necks must be tumbled or trimmed off. Transfer molding, in general, is best suited to small parts.

Injection molded parts. Injection molding of rubber is similar to transfer molding in that the cavities are filled after the mold is closed by forcing stock through runners. The main difference between injection molding of rubber and injection molding of plastics is that the plastics material is fed from a heated cylinder by a piston into a cooler mold from which the finished part is removed as soon as it chills below its distortion temperature. Rubber materials, on the other hand, are injection molded by extruding the compound into a hot mold from a screw and barrel, and the finished part is removed from the cavities while hot.

Advantages of injection molding are similar to those of transfer molding: uniformity, close tolerances, good finish and thin trim flash. Changeover and setup time are relatively long, however, and equipment and maintenance are costly. In general, injection molding is suitable only for long production runs.

Blow molded parts. This molding technique, used for hollow parts, uses either of two methods: 1) pressure is derived from gases generated at curing temperature from decomposition of chemicals inserted into the hollow space when the stock is prepared for loading into the mold; or 2) air is forced through a hollow needle inserted through the mold wall into the cavity.

In either case, the pressure forces the stock against the contours of the mold cavity with sufficient force to shape it and hold it firmly in contact with the mold walls during the molding cycle.

Design factors. Although it is difficult to generalize, all of the following factors should be considered:

Shrinkage—All rubber compounds shrink on cooling from the vulcanization temperature to room temperature. However, shrinkage varies widely from about 0.006 in. per in. to as much as 0.050 in. per in., or more. Allowance for shrinkage depends on curing time, temperature and pressure, and the difference between the thermal expansion of the rubber compound and the mold material. Complex shapes may also cause irregular shrinkage, resulting in distortion of some dimensions. In general, it usually suffices to make the mold 1/64 in. per in. larger in each dimension than the desired finished part.

Wall thickness—Solid objects as thick as 12 in. and sections as thin as 0.005 in. are possible. Over such a wide range, however, compounding and vulcanization procedures must be designed to fit the type of product to be molded. Uniformity of wall thickness is not always essential; however, because

optimum vulcanization, or cure, is a function of time and temperature, very great differences in wall thickness are not desirable.

Draft—No draft is required on parts up to 85-90 durometer. Above this hardness range, parts more than ½ in. thick generally require a draft of ½-1 deg. If the part has a deep recess or a hole through it, the taper need only be on the core or the cavity, but not on both.

Undercuts—Both external and internal undercuts are probably achieved in molded rubber with greater ease than in any other material. However, on materials of 80-90 durometer they should be avoided.

Holes—There are few limitations regarding molded-in holes. Difficulties arise only with very small diameters, great depth, excessive hardness of compound, and improper mold design.

It is possible to produce parts with holes as small as 1/32 in. in dia and 5/8 in. long. Blind holes are more difficult to produce due to the possibility of pin breakage. However, blind holes ⅛ in. in dia and 1½ in. deep are possible. Threaded holes in soft rubber are not practical unless the threads are coarse wood or bottle threads.

Tolerances—Dimensional accuracy of molded rubber parts is controlled primarily by 1) the type of compound used, 2) the shape and thickness of the part, 3) mold design and construction, 4) shrinkage, and 5) amount of trim and finish.

Standard Rubber Manufacturers Assn. tolerances for precision molding (Class 1) and "Commercial" products (Class 3) are given in the tables below.

Design Rules.

1. Locate the parting line so that flash can be easily removed. On compression molded parts, for example, parting lines should be at the largest diameter.

2. Indicate on the part drawing exactly where flash is not permissible. Also give allowable limits on flash.

3. Avoid undercuts with 80-90 hard rubber. Provide a slight draft with 90-95 hard rubber. Although softer compounds do not require draft, it does facilitate removal from the mold and should be incorporated wherever possible.

4. Avoid fragile edges, allowing at least 1/16 in. thickness for all flanges.

5. Keep radii at edges and corners at least 1/32 in. for strength, good appearance and breakage resistance.

6. Keep sections as light and uniform as possible to reduce curing time and to insure uniform cure.

7. Construct molds with standard machine finish unless special finish is required. Polished or chromium-plated mold cavities are expensive and should be avoided.

8. Use a tolerance of ±15% when shear or compression rates are specified.

Die, Lathe Cut Parts

Lathe cut parts are usually cut from extruded tubing or sleeves and are used for such things as gaskets, packings, disks, washers, seals, spacers, rings, bushings, etc. There are several different methods of cutting: the most accurate (and also most expensive) is hand cutting; the most economical (and least precise) is guillotine cutting.

Die cut parts are cut from vulcanized sheet or slabs with inexpensive steel dies. Flat parts with

TOLERANCES OF MOLDED PARTS (CLASS 1)

Size, in.	Dimensions Not Affected By Flash	Dimensions Measured Across Flash
0.000–0.499	±0.003	±0.005
0.500–0.999	±0.005	±0.008
1.000–1.999	±0.008	±0.010
2.000–2.999	±0.010	±0.013
3.000–3.999	±0.013	—
4.000–4.999	±0.015	—
5.000–7.999	±0.020	—

TOLERANCES OF MOLDED PARTS (CLASS 3)

Size, in.	Dimensions Not Affected By Flash	Dimensions Measured Across Flash
0.000–0.499	±0.010	±0.015
0.500–0.999	±0.010	±0.018
1.000–1.999	±0.015	±0.020
2.000–2.999	±0.020	±0.025
3.000–3.999	±0.025	±0.030
4.000–4.999	±0.030	±0.035
5.000–7.999	±0.045	±0.050

TOLERANCES OF EXTRUDED PARTS

Tubing						Special Shapes	
Length, in.		Inside Dia, in.		Outside Dia, in.		Cross-Sectional Dimension, in.	
Range	Tol	Range	Tol	Range	Tol	Range	Tol
0–1½	±1/64	0–½	±0.008	0–½	±1/64	0–¼	±1/64
1½–10	±3/64	½–1	±1/64	½–1	±1/32	½–½	±1/32
10–40	±1/16	1–3	±1/32	1–2	±3/64	½–1	±3/64
40–60	±¼	—	—	2–4	±1/16	1–2	±1/16

continued on next page

Rubber Parts

large holes or cutouts are often cheaper to mold, however, due to waste in die cutting.

Practically any rubber material can be die cut into almost any shape and size, up to 19 × 36 in. (larger parts are made by cementing). Thickness of die cut parts generally runs from about 3/32 to 1 in., in 1/16-in. gradations. With thickness above ⅛ in., some concavity develops on punched edges. This is more pronounced the thicker and softer the material is. Holes more than half the thickness of the material are difficult to punch satisfactorily.

Tolerances for die cut parts are as follows:

Thickness, in.	Tolerance
1/4-1/32	±0.008
1/16-1/8	±0.016
5/32-3/8	±0.031
1/2 and over	±0.047

Extrusions

Extrusion, like calendering, is widely used to make blanks for molding. However, it is also a widely used method of forming rods, tubes, strips, channels, gaskets and other shapes.

An extruded rubber part differs from a molded rubber part in two ways: 1) the rubber is forced through a die under pressure, and 2) vulcanization does not take place in a cavity. In the process, the rubber compound is first warmed on a mill and then fed directly to the extruder in a continuous strip. The compound is forced through the die opening by a screw. The extruded material is then cut and the parts vulcanized under open steam in specially designed heating chambers.

The primary advantage of extruded parts is low setup and die costs and, consequently, low cost of finished parts.

Primary disadvantages are inability to hold close dimensional tolerances and limitations on shape and size of part. Tolerances must be liberal because the rubber swells on extrusion and shrinks when vulcanized. In some cases, swelling can amount to more than twice the die opening, depending on type of compound used, softness desired, plasticity of the rubber, and temperature, pressure and rate of extrusion. As a result, size and contour of the die must be adjusted to insure proper dimensions on the finished part.

Tolerances for extruded tubing and special shapes are given in the accompanying table.

Rubber-to-Metal Molding

Many molded rubber products are functional only because they are bonded to metal parts. Typical of these parts are motor mounts, seals, instrument vibration dampeners, army tank tread blocks and industrial caster wheels. Primary characteristics of rubber-to-metal moldings are: absorption of shock loads, dampening of mechanical vibrations, suppression of noise, high strength and durability.

In general, rubber is bonded to mild steel, cast iron, stainless steel, die cast aluminum, bronze, brass and other metals and alloys. Recently, however, rubber has been successfully bonded to plastics, wood and other nonrigid materials. Adhesive strength of rubber-to-metal bonds often exceeds the tensile strength of the rubber compound itself.

When considering rubber-to-metal molding, cost must be taken into account. The quality or type of bond desired determines to a great extent the ultimate cost of the rubber-to-metal part. For example, to obtain adhesion on such functional parts as motor mounts, very close and costly controls are required on both metal and rubber preparation. With nonfunctional parts, such as some pads and bumpers which require only enough adhesion for assembly, these costly controls are not necessary.

The same adhesion values are not necessarily obtained with different metals. Iron and mild steel give the highest values. Different rubber compounds also give different values. Low tensile compounds, for example, do not give as high an adhesion value as high tensile compounds.

Adhesion. The two most commonly used methods of obtaining adhesion between rubber and metal involve 1) the use of special adhesives, and 2) a special brass plating on the metal surface.

Rubber containing sulfur may be bonded directly to yellow brass parts by molding against the metal under sufficient pressure. The bond obtained during vulcanization is believed to result from interaction of sulfur with the brass and the elastomer.

Most rubber compounds will not adhere directly to steel as they will to brass. In those cases an organic adhesive is used. To prepare the metal for adhesive bonding, it is first degreased and then blasted with sand or steel grit. The adhesive is applied and the rubber compound is molded to the prepared metal part.

There is no universal bonding agent and the selection of one is dependent upon the elastomer and the rubber compound used, the metal surface, the service requirements of the bonded part, and factory operating conditions.

Rubber-to-steel bonds can also be obtained by electroplating brass on the steel surface and then bonding the rubber to the plated coating as if it were a brass part. However, there are certain disadvantages to this method: plating conditions must be very carefully controlled because slight variations affect bond strength; and installation of brass plating equipment is costly.

Design rules. The following rules should be observed:

1. Keep heat buildup in the rubber compound to a minimum to prevent premature bond failure. The two most common causes of heat buildup are excessive ambient temperatures and undersize design.
2. Allow adequate space for distortion of the rubber under load.
3. Use metal inserts free from burrs and sharp edges to avoid cutting action on the rubber when under distortion.
4. Use fillets or design rounded metal corners to avoid areas of concentrated stress.
5. Keep loads on bonded surfaces no higher than about 250 psi.
6. Design metal inserts with close tolerances on dimensions which register in the mold. If large tolerances are necessary, they should be on the minus side.
7. Use smooth metals for best adhesion. Corrugations, knurling, etc., decrease adhesion.
8. Use large fillets at sections where rubber joins steel on flexed or stressed parts.

Composite Materials

Composite materials actually include a wide range of divergent compositions. This discussion, however, will be limited to what are perhaps the six most frequently specified types: plastics-metal laminates, metal-wood laminates, clad metals, honeycomb sandwich structures, combination plastics laminates, and bi-metallic castings.

Each of the different compositions is designed to satisfy specific service requirements and offers special properties and characteristics. Composites are sometimes designed for high structural strength, sometimes for insulation, sometimes for decorative appeal and sometimes for special purposes. In general, all composite materials offer some of the following characteristics: low weight, low cost, simplified construction, high strength or stiffness, thermal insulation, fire resistance, moisture or water resistance, vibration or sound dampening, elimination of size limitations, atmospheric and chemical resistance, abrasion and wear resistance, and improved decorative qualities.

Plastics-Metal Laminates

Although there are many possible combinations, vinyl-metal laminates probably account for about 90-95% of all plastics-metal laminates now used. A relatively new laminate, polyester-steel, is discussed briefly below.

The wide range of uses for vinyl-metal laminates includes electrical products, transportation equipment, luggage and carrying cases, household products and building applications. Their main advantages are: high decorative appeal, strength and light weight, resistance to wear and abrasion, resistance to most chemicals, and ease of fabrication.

Materials. In general, any ferrous or nonferrous base metal can be used. However, the three most common metals in use today are cold rolled steel, aluminum and magnesium. A steel base is selected where strength and low cost are dominant design factors. Aluminum is used where lightness and/or corrosion resistance is required. Magnesium is usually used only when extreme lightness is required (e.g., luggage and carrying cases).

Any of these base metals can be laminated with vinyl on one or both sides. Ordinarily, a single-side laminate is sufficient for product interiors. However, a double-side laminate may be required if the reverse side of the laminate must have special properties.

The reverse side of a laminate may also be provided with a wide variety of organic finishes or electroplates. For added decorative appeal and resistance to rust and corrosion, reverse sides can be easily plated with zinc, chromium, copper, cadmium or nickel without damaging or discoloring the vinyl layer.

Properties.

Appearance—Probably the most noteworthy characteristic of vinyl-metal laminates is their outstanding appearance. The number of textures and colors that can be produced is almost unlimited. Typical of the textures now being produced are leathers, textiles, wood grains, high gloss matte finishes, nonreflecting matte finishes, and marbleized finishes. All of these textures can be produced in practically any color.

Chemical resistance—The high-molecular-weight polyvinyl chloride resins used in vinyl laminates are inherently chemically stable. However, some types of vinyl films are given a clear protective coating of up to 2 mils for added resistance to corrosion, staining, abrasion and handling. In addition, vinyl laminates are also resistant to 48-hr exposure to such common media as petroleum, alkalis, citric acid, Clorox, ammonia, milk, animal oil, vegetable oil and greases.

Abrasion, wear and heat resistance—Vinyl-metal laminates have outstanding abrasion and wear resistance. In general, maximum recommended operating temperature is about 200 F. The laminates show no loss of adhesion and no tendency to delaminate after 600-hr exposure to 150 F. Laminates exposed to 210-250 F will not show any surface damage unless pressure is applied to the surface while it is hot.

Thickness. A vinyl film of 10 to 15 mils has proved satisfactory for most applications. However, films as thin as 4 mils and as thick as 25 mils, and higher, are available. Thickness of the base metal depends on the structural requirements of the application. The practical laminating thicknesses for steel are 0.012 in. to 0.06 in., for aluminum 0.016 in. to 0.125 in., and for magnesium 0.016 in. to 0.081 in. Sheets are available in sizes up to 52 × 120 in. and larger. Also, coil stock in 40-in. widths is available in almost any length.

Forming, joining. Vinyl-metal laminates are easily drawn and formed on existing equipment. The maximum draw that can be obtained is generally limited by the forming properties of the base metal. However, any draw that can be made in one operation is satisfactory; the metal cannot be annealed. Any die lubricant can be used; however, water-soluble or silicone-base lubricants are recommended.

Vinyl-metal laminates can be also crimped, bent and spun. Normal cutting and shearing operations are permissible provided the vinyl side of the laminate is exposed to the cutting edge. When shearing a double vinyl laminate, the side with the thinner vinyl film should be away from the cutting edge.

Vinyl-metal laminates can be readily fastened with conventional sheet metal screws, bolts, rivets, lock nuts, and speed nuts through drilled or pierced holes. Brazing and soldering do not produce very strong joints and are used only in a few isolated applications.

A resistance welding technique has recently been developed which makes it possible to produce a high strength weld on the back of a steel laminate without indenting or burning the vinyl or affecting its bond. Welding is accomplished by using two copper alloy electrodes that contact the workpiece on the same side.

Polyester-metal laminates. This relatively new plastics-metal laminate, consisting of polyester resin on strip steel, offers the following characteristics: good moisture, abrasion, weather and stain resistance; and the ability to be deep drawn, lock seamed, roll formed, sheared, crimped, bent and pierced. They can be joined only by mechanical means at present. However, new heat joining methods and adhesives are being investigated.

The laminate is available in any color and most textures, and is produced in widths up to 48 in. in continuous rolls.

continued on next page

Composite Materials

Metal-Wood Laminates

Although many combinations of metal facings and wood cores are possible, the most commonly used materials are steel and aluminum faces and plywood cores.

Metal-wood laminates are used for a wide range of applications, including truck and trailer side panels; railway car interiors, bulkheads and doors; kitchen cabinets; instrument boxes and cabinets; bus and truck doors; locomotive sheathing; foundry patterns; outdoor signs; and architectural applications of all kinds.

Properties. The primary advantage of metal-wood laminates is excellent rigidity at low weight and cost. A typical ⅜-in. thick laminate, made of plywood sandwiched between faces of zinc-coated steel, has a stiffness factor equal to that of 1/16-in. thick solid oak, ⅜-in. thick aluminum plate, or ¼-in. thick steel plate. For the same conditions, 1 sq ft of the metal-wood laminate weighs 3.3 lb, as compared to 2.8 lb for oak (which has nearly twice the thickness), 5.4 lb for aluminum plate, and 10 lb for steel plate.

Other characteristics include: versatility (the laminates are available in a wide range of sizes, thicknesses, edges, cores and faces to meet specific end service requirements); uniformity; fire resistance; smooth surfaces; sound dampening; and ease of fabrication.

Materials. Virtually any combination of metal and wood can be produced. The three most widely used combinations are: 0.029-in. thick zinc-coated steel bonded to plywood on one or both sides; 0.020-in. thick aluminum alloy 3003 bonded to plywood on one or both sides; and 0.025-in. thick type 18-8 stainless bonded to plywood on one side only or with zinc-coated steel on the other.

Other laminates sometimes used involve faces of monel, lead, porcelain enameled steel, and a combination of aluminum and steel; and cores of wood veneer, wallboard, hardboard, balsa wood and insulation board.

Sizes, thicknesses. Standard widths, lengths and thicknesses of wood-metal laminates are as follows: for laminates consisting of zinc-coated steel on one or both sides or aluminum on one or both sides, available widths range from 30 to 48 in.; available lengths range from 72 to 144 in.; and thicknesses range from ¼ to 1 in.

For laminates consisting of stainless steel on one side alone or with zinc-coated steel on the other side, widths are 30, 36, or 48 in.; lengths are 96 or 120 in.; and thicknesses range from ¼ to 1 in. Greater thicknesses can be obtained if desired.

Tolerances on length and width are the same as those for the metals used. Thickness tolerances (including the metal faces) are held to ±0.015 in.

Forming, joining. Metal-wood laminates can be easily worked with standard tools. Generally, selection of the cutting tools should be determined by the metal facing. The laminates can be sawed, drilled, bored, notched and routed.

Although metal-wood laminates are usually used as flat sheets, panels with metal facing on one side only can be curved to a certain degree. For example, a ¼-in. panel with steel on one side can be bent to a 9-in. radius.

Metal-wood laminates can be joined by soldering (except those with aluminum faces), adhesive bonding and mechanical fastening, including sheet metal screws, bolts, machine screws, sleeve nuts, etc. For hinges, locks, hangers, handles and other hardware fittings, tapping plates should be used to eliminate through fasteners and add strength.

STIFFNESS AND WEIGHT OF PLYWOOD-METAL LAMINATES[a]

Plywood Thickness, in.	No. of Plies	EA, 1000 lb/in. width [b]		EI, 1000 sq in.-lb/in. width [c]		Bending Moment (max), in.-lb/in. width		Weight, lb/sq ft
		Long.	Trans	Long.	Trans	Long.	Trans	
STEEL (0.024-in.) BOTH SIDES								
¼	3	1671	1628	28.9	27.3	388	366	2.79
⅜	3	1755	1755	63.8	58.8	604	556	3.13
⅜	5	1786	1724	62.7	59.9	596	566	3.13
½	5	1936	1784	112.5	104.8	822	765	3.53
⅝	5	2060	1870	175.1	163.8	1040	974	3.83
¾	5	2070	2070	249.7	239.6	1250	1200	4.23
¾	7	2070	2070	254.2	235.2	1270	1180	4.23
1	7	2185	2375	450.0	440.0	1720	1680	5.00
1⅛	7	2385	2385	594.1	579.2	2030	1975	5.35
ALUMINUM (0.016-in.) BOTH SIDES								
¼	3	551.6	508.8	7.7	6.0	131	103	1.25
⅜	3	635.0	635.0	18.4	13.4	217	158	1.58
⅜	5	666.6	603.2	17.4	14.5	205	171	1.58
½	5	816.0	664.0	34.2	26.6	308	240	1.98
⅝	5	940.0	750.0	56.1	44.7	410	327	2.28
¾	5	950.0	950.0	81.3	71.1	499	437	2.68
¾	7	950.0	950.0	85.7	66.6	527	409	2.68
1	7	1065.0	1255.0	158.4	148.2	738	690	3.46
1⅛	7	1265.0	1265.0	211.1	196.2	875	813	3.81

[a] Longitudinal and transverse refer to direction of plywood face grain with respect to span length.
[b] EA is modulus of elasticity times cross-sectional area. Must be considered in composite materials.
[c] EI values computed on following basis: E for fir plywood is 1.6×10^6 psi for long plies and 80×10^3 psi for transverse plies; ultimate fiber stress in bending for fir is 8000 psi; for steel, E is 30×10^6 psi and ultimate fiber stress in bending is 60,000 psi; for aluminum, E is 10×10^6 psi and ultimate fiber stress is 24,000 psi.

Combination Plastics Laminates

Plastics laminates combined with other materials can provide special combinations of properties that are not obtainable with any single material.

These combination laminates consist of various plastics laminates bonded to such other materials as copper, aluminum, rubber, etc. Specific characteristics offered by combination laminates include: 1) high strength-weight ratio; 2) excellent resistance to corrosion and chemicals; 3) great range of electrical characteristics; 4) dimensional stability over a wide temperature range; 5) high rigidity and strength for soft sealing materials; 6) good bearing surfaces; 7) great range of frictional characteristics; and 8) good fabrication characteristics and low production costs.

Materials, forms. Theoretically, any material can be combined with plastics laminates by adhesive bonding. However, because of similarities in design requirements for various types of end uses, several combinations have become somewhat standardized.

The most common plastics laminates used are the paper-base phenolics, such as NEMA grades XXXP, XX, XXP and XP. Other grades used quite frequently are C, CE, L and LE fabric-base phenolics; G-3 glass-melamine; G-5 glass-phenolic; and G-10 glass-epoxy.

The materials most commonly supplied in combination with plastics laminates are copper, natural and synthetic rubbers, cork, asbestos, steels, aluminum alloys, vulcanized fibre, and polyester and cellulose acetate films. Two grades of plastics laminates may also be combined.

Combination laminates are available in sheet, rod or tube form. In sheet form, the plastics laminate can be specified on one or both sides, or sandwiched between laminae of other materials. When a tubular form is used, the combination material consists of a plastics laminate covering a metal tubular core.

Properties, uses.

Copper-faced laminates—Probably the most widely used combination laminates are the copper-faced laminates used for printed circuits. Laminates are available with electrolytic or rolled copper foil in thicknesses of 0.00135 in. (1 oz), 0.0027 in. (2 oz) or greater, bonded to either one or both sides of an XXXP base. This grade is generally used because it has excellent insulation resistance, good punching qualities, and low dielectric losses even under high humidity conditions.

Bond strength for most copper-faced laminates is between 4 and 8 lb per in. width for 1-oz foil and slightly higher for 2-oz foil. Copper-faced laminates made by a new process have about twice the bond strength, but lower surface resistivity.

Vulcanized fibre-clad laminates—These combination laminates provide high arc resistance and a wide range of toughness, impact strength, rigidity and appearance, depending on the grade and thickness of the laminate and the fibre. They are used for such things as switchgear in both low and high voltage applications.

Asbestos-clad laminates—Asbestos paper bonded to plastics laminates provides a combination with high heat and arc resistance and is used for arc barriers and reflectors in high voltage arc interrupting devices.

Aluminum-clad laminates — These combination laminates are used extensively for engraving stock. They are also used as plate holders for x-ray machines where aluminum acts as the shield. Used as a piston head in aircraft shock struts, it provides the following advantages: it eliminates metal-to-metal contact, it is lightweight, mechanically strong, shock resistant, impervious to hydraulic oils, and stable over a wide temperature range. Aluminum-clad laminates also offer possibilities as a printed circuit material, but soldering remains a problem.

Beryllium copper-clad laminates—This composite material offers possibilities for printed circuits because of beryllium copper's good conductivity and nonmagnetic characteristics.

Silver and gold-faced laminates—The extremely high electrical conductivity of silver and gold makes these combination laminates particularly promising as electrical contact materials. The plastics laminate provides strength and insulation properties.

Bimetallic Castings

Bimetallic castings are actually composite materials in which aluminum and magnesium alloys are molecularly bonded to steel, stainless steel and other ferrous metals.

In the process, the light metal is cast against a specially processed surface of the ferrous metal using any of the standard casting methods—sand, permanent mold, plaster mold, or pressure die casting. Typical uses for these composite materials are brake drums, engine cylinders, clutch rotors, guided missile control fins, impellers, pistons, gears, hydraulic manifolds and valve housings.

Main advantage of bimetallic castings is the ability to combine the strength, hardness, fatigue resistance, etc. of ferrous metals with the lightweight, high heat conductivity and other characteristics of light metals.

Metals used. Light metals used are pure aluminum and magnesium and any of their common casting alloys. Aluminum alloys include 43, 132, 142, 195, 220, 356, Almag 35, and Frontier 40-E; magnesium alloys include AZ92A, AZ63A and AZ91C.

Ferrous metals include gray, malleable, ductile and austenitic cast irons; and carbon, alloy and stainless steels. Aluminum and magnesium alloys can also be bonded to Inconel, the Nimonics, nickel, titanium and some other alloys.

Properties. In the case of iron and aluminum, the bond, which is essentially an intermetallic compound of the two, has a tensile strength of 15,000 psi and can withstand shearing stresses of the order of 7000 psi. The bond retains its properties at temperatures above 500 F and is both vibration-proof and leakproof. Galvanic attack is impossible because there are no voids at the interface.

Design. The major factor to be considered in designing bimetallic castings is the difference in expansion coefficients between the light metals and the various ferrous metals. Despite the difference, separation is generally prevented by the strength of the intermetallic bond.

Special attention must also be given to the selection of light metal casting alloys. It is generally not possible to solution treat (T-6) because of the thermal shock placed on the bond during quenching. Alloys specified should, therefore, either be usable in the as-cast condition or be responsive to artificial aging.

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Composite Materials

Honeycomb Sandwich Structures

A wide variety of core and facing materials are possible with honeycomb sandwich structures, each composition offering a special combination of properties to meet specific end service requirements. In general, all honeycomb sandwich structures offer these characteristics: high strength-to-weight ratio; resistance to heat transfer and vibration; use of nearly any structural material; close tolerances; high speed production; and ease of fabrication.

Honeycomb sandwich structures are used in practically every aircraft or missile flying today. Typical of aircraft uses are wings, ailerons, rotor blades, trailing and leading edges, doors, flooring, bulkheads, stabilizers, radomes, fuselage sections, elevators and rudders. They are also used for such commercial applications as building wall panels, flooring for trailers, small boat hulls, shipboard doors and bulkheads, table tops, pallets, truck panels and doors, stressed skin buildings, furniture, etc. Some recent applications include gas turbine seals, oil seals, heat radiators, shock absorbers, electromagnetic shielding and noise suppressors.

Honeycomb sandwich theory. Honeycomb structures can be best compared to I-beams. The facings correspond to the flanges, the object being to place a high density, high strength material as far from the neutral axis as possible and thus increase the section modulus. The honeycomb core is comparable to the web of an I-beam which supports the flanges and allows them to act as a unit. The honeycomb, like the web, carries the shear stresses. However, honeycomb differs from I-beam webs in that it maintains continuous support for the facings, allowing the facings to be worked up to or above their yield strength without crimping or buckling. The adhesive which bonds the honeycomb to its facings must be capable of transmitting shear loads between the two components, thus making the entire structure an integral unit.

When the sandwich panel is loaded as a beam, the honeycomb and the bond resist shear loads while the facings resist the moments due to bending forces, and hence carry the tensile or compressive load. When loaded as a column, the facings alone resist the column forces while the core stabilizes the facings to prevent buckling.

Although comparable to I-beams, honeycomb sandwich structures are actually more efficient. The combination of high density facings and low density cores provides a much higher section modulus per unit density than any other known construction method. Thus, for an equivalent rigidity factor, weight of an aluminum-faced honeycomb sandwich structure beam is only ⅛ that of birch plywood, 1/10 that of solid aluminum and 1/16 that of solid steel.

Facing materials. Theoretically, any thin, bondable material with high tensile or compressive strength-weight ratio is a potential facing material for honeycomb panels. The materials most commonly used for facings are aluminum, steel, glass-reinforced plastics and wood. The facing can be finished with special exterior effects, such as decorative paints and enamels, or rough surfaces for anti-skid floor panels. In some cases, the skin may be embossed with a regular pattern to provide a special effect.

Aluminum—Alloys such as 7075-T6, 2024-T3 and 2014-T6 are commonly used facing materials in thicknesses from 0.010 in. to 0.064 in. for structural, as well as nonstructural, applications. Aluminum is generally not used for applications where temperatures exceed 400 F for long periods of time. Anodizing or coating with a protective resin can be done where increased corrosion resistance is desired.

Stainless steel, superalloys—Because of their good strength at elevated temperatures, these facings are finding increased usage in aircraft. Some of these facings have been found to perform satisfactorily at tempertaures as high as 2000 F. Porcelain enameled steel is also available for special applications.

Glass-reinforced plastics—Where parts must have a complex contour, glass-reinforced plastics are ideal. They also offer these special advantages: excellent weight control—it is easy to build up material where it is needed and leave faces thin where excess material is not needed; excellent insulation and heat reflections; excellent medium temperature strength; high strength-weight ratio; high impact strength; and compatibility with other materials.

Plywood—Plywood facings are available for both structural and nonstructural applications. The most common use of plywood facings, however, is in interior and exterior doors of buildings. Plywood facings for doors are usually bonded to a paper honeycomb core.

Resin-impregrated paper—Paper facing materials are generally used for flat, nonstructural panels such as interior walls and partitions.

Core materials. Honeycomb cores are produced from a number of materials, including aluminum, glass or asbestos-reinforced plastics, and paper. In addition, stainless steel, titanium, and some superalloy cores have been developed for special environmental applications. Theoretically, any metal that can be made into a foil and then welded, brazed or adhesive bonded can be made into a honeycomb.

Aluminum—Cores are supplied in the expanded or unexpanded form in thicknesses from 0.060 in. to 18 in. or more. By varying cell size and gage, honeycomb density can be closely controlled over a wide range. Aluminum core is available in cell sizes varying over a range of densities from 1.2 to 8.1 lb per cu ft.

The two most common aluminum alloys used are 3003-H19 and 5052-H39. The major difference between the two alloys is that the 5052 alloy has about 20% more compressive and shear strength at equal densities. Alloy 5056 is now available in a few cell sizes and densities.

Stainless steels, superalloys—These alloys are generally used where service temperatures are too high to permit use of aluminum or glass-reinforced plastics (this is also true of titanium). Alloys most

commonly used for temperatures above 900 F are these heat treatable stainless alloys: 17-7PH, PH 15-7Mo, AM-350 and AM-355; and these heat treatable superalloys: A-286, Inconel X and L 605.

Non-heat treatable metals, such as the plain austenitic stainless steels (AISI 321) and Inconel, are used for light loaded parts at temperatures up to about 1800 F. Above 1800 F, only the refractory metals, such as molybdenum, tantalum or columbium, can be used.

Titanium—Although titanium honeycombs are more or less competitive with stainless steel, their use is limited by difficulties encountered in forming and machining. Alloys most commonly used, however, are Ti-75, 6 Al-4 V, A110 and the DOD alloys.

Glass-reinforced plastics—Many formulations are available, most of which are made by impregnating a glass cloth with resin, expanding to a honeycomb structure, curing, and repeatedly coating with a polyester, phenolic, epoxy or silicone resin. These cores are generally available in cell sizes ranging between 3/16 in. and ⅜ in., and in thicknesses ranging from 0.060 in. to 18 in. Density, which ranges from 2.5 to 16 lb per cu ft, can be varied by changing cloth thickness and amount of coating. Glass-plastics cores are normally formed in regular blocks or slices but are available in slices pre-curved to specified contours.

Paper—Paper honeycomb is usually impregnated with a phenolic resin for strength, rigidity and moisture resistance. Cell sizes vary between ⅛ in. and 1.2 in. Standard core thicknesses are available from ¼ in. to 6 in. Depending on paper thickness and amount of impregnation, densities range between 1.5 and 4.0 lb per cu ft.

Design. The loads, their orientations and the configuration of the part determine the type of stresses which must be resisted. Generally, these stresses fall into the following categories: compression, tension, shear, peel and buckling. Honeycomb sandwich structures are almost always designed for flexural loading and therefore consist of thin, high density facings bonded to a relatively thick, low density honeycomb core.

The same formulas used to calculate stresses in I-beams can be used to determine the stresses developed in honeycomb panels. Other important design criteria include the following:

Creep—Creep properties of a honeycomb panel under load are primarily a function of the adhesive, the service temperature and the time at temperature. With proper selection of the adhesive, most creep requirements can be easily met.

Impact—In some cases, high concentrated impact loads, especially in flooring applications, outweigh all other design considerations. A thin facing material will generally satisfy all tensile and compressive requirements, but thicker facings are usually specified to resist impact. A thicker facing distributes the impact load over a wider area, thus reducing the stress on the core.

Often floor panels are designed with different facing thicknesses to provide maximum resistance at areas of greatest impact. When panels are subjected to extremely high impact loads, a thin wood veneer or layer of phenolic laminate is bonded to the facing.

Fatigue—Honeycomb sandwich structures are probably more resistant to fatigue than any other construction due to the continuous nature of the bonded surface. The most critical parts of the structure in regard to fatigue are the attachment points. When subjected to fatigue tests, a panel will usually fail at these points.

Environment—Temperature, time at temperature, moisture, and the existence of various fluids and gases are all important design considerations. However, all of these factors are dependent upon the materials being used. Suggested sandwich structures for elevated temperatures are given in the table at the bottom of this column.

Joining. Honeycomb sandwich structures can be joined by several methods.

Generally, honeycomb structures cannot withstand the compressive loads caused by bolts, rivets, screws, and other mechanical fasteners. However, a great number of inserts and special fasteners have been devised to overcome this problem. Inserts include wood, plastics or metal strips; molded-in plastics blocks; and aluminum spacer inserts.

Stainless steel and other heat resistant honeycombs can be joined by resistance welding and brazing.

The most common method used is adhesive bonding. Several types of adhesive are used: rubber-base cements, a combination of thermosetting resins and elastomeric polymers, epoxy resins, epoxy-phenolic systems, and duplex tapes consisting of a supported film adhesive (combination thermosetting resin and elastomeric polymer) on one side and a film of semi-liquid epoxy on the other.

RECOMMENDED HIGH TEMPERATURE STRUCTURES

Temp, F	Core	Facing	Remarks
Up to 350.....	Aluminum	Aluminum	Retains ¾ strength at 300 F; 2/3 at 350 F
Up to 500.....	Glass-reinforced plastics	Steel or titanium	Retains good strength at 500 F; some resins begin to deteriorate after few hours
350-1000.....	Steel	Steel or titanium	Depends on brazing materials, alloy used and temper; silver brazing alloys good to 850 F

Clad Metals

Surface ↓	Base Metal		Critical Functions, Properties	Typical Applications
	Metal	Form		
Aluminum and Its Alloys				
Aluminum [a]	Low carbon steel	Strip	High temperature oxidation resistance. At 1000 F forms alloy with 85% emissivity. Cheaper than carbonated nickel or nickel-clad steel. Conserves nickel	Anode plates for electronic receiving tubes
Aluminum [b]	Low carbon steel	Strip	Same as above, but suitable for higher temperatures	Anode plates for receiving tubes where close spacing makes temperatures too high for aluminum
1100	Aluminum (2024)	Sheet	Atmosphere resistance. Galvanic protection. Strong base	Aircraft frames, cooking utensils, hardware
6053	Aluminum (2014)	Sheet	Atmosphere and wear resistance. Galvanic protection. Workable base	Power shovel bails, aircraft fittings, heavy duty forgings
6053	Aluminum (5056)	Wire	Same as above	Insect screening
7072	Aluminum (3003 or 3004)	Sheet	Atmosphere resistance. Galvanic protection. Workable, weldable base	Cooking utensils, gasoline and oil tanks, bus and train trim
7072	Aluminum (3003)	Tube	Same as above	Heat exchangers
7072	Aluminum (7075)	Sheet	Atmosphere resistance. Galvanic protection. Strong base	Aircraft structural parts
Copper and Its Alloys				
Brass [c]	Low carbon steel	Strip	Decoration. Atmosphere resistance. Good solderability	Cosmetic cases, frames, gaskets
Brass [d]	Low carbon steel	Wire	Decoration. Atmosphere resistance. Strong base. Conserves brass	Curtain rods, indoor television antennas, lamp stands
Copper	Carbon steel	Wire, ribbon	Electrical conductivity. Atmosphere resistance. Strong base. Conserves copper	Lead-in wires for electronic tubes, communication and power lines, springs
	Aluminum (1100 or 5052)	Sheet, strip, tubing, wire, bars	Thermal, electrical conductivity. Good solderability. Lightweight base. Conserves copper	Waveguides, variable condenser blades, heat transfer fins, jewelry, shims, bushings
	Beryllium copper (25)	Strip	Electrical conductivity. Good spring properties	Current-carrying springs
	Low carbon steel	Strip	Atmosphere resistance. Thermal conductivity. Good solderability. Strong base. Conserves copper	Gaskets, automotive radiator tanks, electrical contacts and switches, immersion heater base plates
	High carbon steel	Strip	Electrical conductivity. Plating base. Good spring properties	Clips, thin-blade or spiral-type springs
	Low alloy steel (with boron)	Wire	Electrical conductivity. Atmosphere resistance. Strong base. Conserves copper	Grid support rods for electronic tubes, communication lines, plated costume jewelry
	Carbon or low alloy steel	Plate, heads	Resistance to corrosion, erosion. Conserves copper	Chemical process equipment
Cupro-Nickel	Low carbon steel	Strip	Same as above	Chemical process equipment
Phosphor Bronze [e]	Copper	Strip	Good spring properties. Base has high electrical conductivity	Current-carrying springs and blades
Gold and Its Alloys				
Gold [e]	Bronze, nickel-silver, nickel, sterling silver	Strip, tubing wire	Decoration. Atmosphere resistance. Relatively low cost base	Jewelry, including watchcases, bracelets, rings, lockets
Gold [f]	Copper, brass, nickel, monel	Strip	Chemical resistance. Relatively low cost base	Bursting disks, other chemical process equipment
Lead and Its Alloys				
Lead [g]	Copper, low carbon steel	Tubing	Chemical resistance. Good strength, high thermal conductivity	Heat exchanger coils for chemical process equipment
Lead	Low carbon steel	Plate, sheet, strip, rod	Chemical resistance. High density. Strong base	X-ray, radium, nuclear and chemical equipment

[a] ½% silicon. [b] ½% silicon with 330 nickel on other side. [c] 70–30 or 85–15. [d] Over copper. [e] 10 K or more. [f] 14 K or more. [g] ASTM B29.

Clad Metals

Surface ↓	Base Metal		Critical Functions, Properties	Typical Applications
	Metal	Form		
Nickel and Its Alloys				
Inconel, Monel	Carbon or low alloy steel	Plate, heads	Resistance to corrosion, erosion. Low cost base. Conserves nickel	Process equipment
Nickel	Copper	Wire, ribbon	High temperature oxidation resistance. Electrical conductivity	Electrical circuits subjected to high temperatures
Nickel	Iron or carbon steel	Wire, ribbon	Atmosphere resistance. High temperature oxidation resistance	Grid support rods, lead-in wire for tubes; typewriter key levers, springs
A Nickel	Copper	Wire, ribbon	Corrosion resistance. Electrical conductivity	Electrical circuits subjected to corrosive atmospheres
A or L Nickel	Carbon or low alloy steel	Plate, heads	Resistance to corrosion, erosion. Low cost base. Conserves nickel	Process equipment
L Nickel	Brass, low carbon steel	Strip	Same as above	Process equipment
330 Nickel	Low carbon steel	Strip	High temperature oxidation resistance. High emissivity. Conserves nickel	Anode plates for electronic receiving tubes
Platinum and Platinum Group Alloys, Silver				
All	Copper, brass, bronze, nickel	Strip	Electrical contact properties. Chemical resistance. Low cost base	Electrical contacts, slip rings, chemical crucibles
Platinum	Copper, brass, bronze, nickel	Tubing, wire	High chemical resistance. Low cost base. Thermal conductivity	Heat exchangers for chemical processes
Platinum	Molybdenum	Wire	High work function (low primary electron emission). Refractory base	Grids for tubes, particularly for use with thoriated cathodes
Silver	Copper, nickel	Wire, ribbon	Atmosphere resistance. High temperature oxidation resistance. Electrical conductivity. Low cost base	High temperature coils, high frequency conductors, braiding for radar cables
	Aluminum (1100, 5052)	Strip	Electrical contact properties. Electrical conductivity. Lightweight, low cost base. Decoration	Conductors, contacts in aircraft electrical equipment. Costume jewelry
	Aluminum, brass	Tubing	Electronic transmission characteristics. Low cost base	Waveguides for electronic transmission lines
	Beryllium copper (25)	Strip	Electrical conductivity and contact properties. Good spring and fatigue properties	Contact arms for buzzer circuits, other current-carrying springs
	Copper, brass	Strip	Electrical contact properties. Low cost base	Electrical contacts, slip rings, flexible waveguides
	Invar	Strip	Good electrical contact properties. Low thermal expansion	Television antenna connectors
	Monel, nickel	Strip	Electrical contact properties. Corrosion resistance. Low cost base	Electrical contacts subject to corrosion or excessive wear
	Phosphor bronze (A,C,D)	Strip	Electrical conductivity and contact properties. Good spring properties	Electrical contact springs
Stainless Steel				
Austenitic [a]	Copper	Strip	Resistance to corrosion, erosion. Thermal conductivity. Workable base	Heat exchangers for chemical processes
Ferritic [b]	Copper	Strip	Corrosion resistance. Thermal conductivity. Uniform heat transfer. Workable base. Decoration	Pots and pans
Stainless	Carbon or low alloy steel	Plate, heads	Resistance to corrosion, erosion. Workable, low cost base metal	Process equipment
Stainless	Low carbon steel	Sheet, plate	Same as above. Decoration	Process equipment, auto bumpers, grilles and trim, display cases, sterilizers
Ferritic	Low carbon steel	Strip	Corrosion resistance. Decoration. Workable, low cost base metal	Cooking utensils, auto bumpers, grilles and trim

[a] 304, 310. [b] 430.

DOW | *Now in magnesium and aluminum*

NEW DOW DEVELOPMENTS PROVIDE DESIGNERS WITH ADDED ADVANTAGES IN LIGHTWEIGHT MAGNESIUM

Lightness, ease of fabrication and other features of magnesium contribute to improved designs for many products—from airplanes and missiles to luggage . . . from industrial machinery to cameras. Now, new developments by Dow provide greater design flexibility than ever before—in fabricated components you require, in materials and processes to facilitate your plant's operations.

New sheet is bent without heated dies.

NEW CLOSE SHEET TOLERANCES HELP SOLVE WEIGHT PROBLEMS

When the design problem is stress distribution versus weight, the new, closer magnesium sheet tolerances available from Dow upon special request offer a real advantage. As shown below, new tolerances are one *half* of standard tolerances. This permits designers to provide for required stress distribution, based on minimum thickness, *without* having to accommodate all the extra weight that might occur with the maximum thickness permissible with conventional tolerances.

Especially useful for aircraft and missile designers, this close tolerance sheet is also suggested for use in air-transported equipment or wherever minimum weight is critical.

COMPARISON OF TOLERANCES

48-inch-wide sheet

Gauge	Close Tolerances	Standard Tolerances
.032"	±.0013"	±.0025"
.040	±.0015*	±.003
.050	±.002	±.004
.063	±.002	±.004
.071	±.002	±.004
.080	±.002	±.004
.090	±.002	±.004
.100	±.0025	±.005
.125	±.0025	±.005
.160	±.004	±.008
.190	±.005	±.010

*For HM21A-T8 .040" close tolerance is ±.002".

NEW SPECIAL BEND SHEET ELIMINATES HEATED DIES

Critical bends can now be easily formed at room temperature — *without heated dies*—using Dow's new AZ31B-O Special Bend Sheet. Without cracking, it bends through an angle of 90° around a mandrel radius as small as two times the nominal sheet thickness. Among many suggested applications are housings for electronics equipment, truck cabs, shipping containers, plus such military uses as maintenance and personnel shelters and housings for ground support equipment.

BEND FACTORS

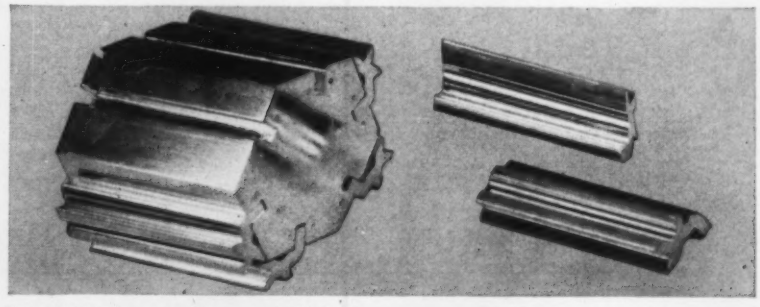
Nominal thickness	Longitudinal bend factor	Transverse bend factor
0.040"–0.100"	2.0	2.5
0.101"–0.190"	2.5	3.0

Tensile yield strength meets Federal Specifications AA-M-44.

PRECISION MAGNESIUM EXTRUSIONS CUT MACHINING COSTS

Dow precision magnesium extrusions provide exact-tolerance finished or semi-finished components and eliminate many costly multiple machining operations. Exacting tolerances are even possible with sharp V's, deep notches, thin slots, sharp serrations, as well as precision diameter tubing. And with precision extrusions, cost of materials is also frequently less because high-property alloys to withstand extensive machining are not needed.

Applications include bearing blocks, impact extrusion stock, parts for business machines, printing furniture, screw machine stock, shaft shear keys, spacers and airfoil configurations.



Exact-tolerance extrusions cut machining costs.

NEW FINISHES BROADEN APPLICATIONS FOR MAGNESIUM

Porcelain enamel, a practically foolproof way to avoid corrosion, can now be applied to magnesium, using a Dow-developed pretreatment to assure adhesion. Suggested applications—display signs, building panels, cooking ware, home appliances, engine parts.

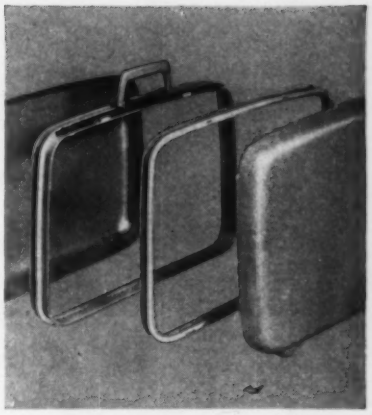
Dow 20 chrome pickle provides a uniform paint-base for casting alloys with high aluminum content.

Dow 21 ferric nitrate bright pickle, as a spray or dip, provides long-lasting protection under clear baking enamels or lacquer.

Clear anodic coating, applied in less than a minute, provides maximum protection under lacquer or varnish, which may be tinted in a wide range of colors.

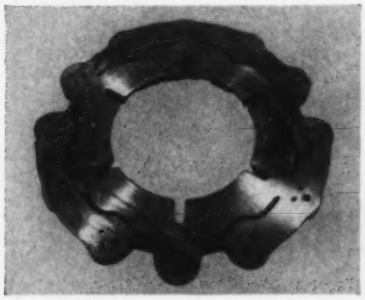
Nickel plating, by immersion instead of electroplating, simplifies processing, improves nickel surface. For electronics equipment, printing plates and cylinders, other surfaces requiring extreme wear resistance.

Vinyl may be laminated before cold-forming magnesium sheets—also bonds to hot-formed shells. For luggage, carrying cases, other applications.



Vinyl-laminate adds sales appeal to carrying cases, luggage.

DOW CASTS MAGNESIUM IN INTRICATE DESIGNS



Casting incorporates tubeless passages.

Cast-in tubeless passageways, thin sections, close tolerances and other intricate designs are all available in castings made in production quantities at Dow's sand and permanent mold foundry.

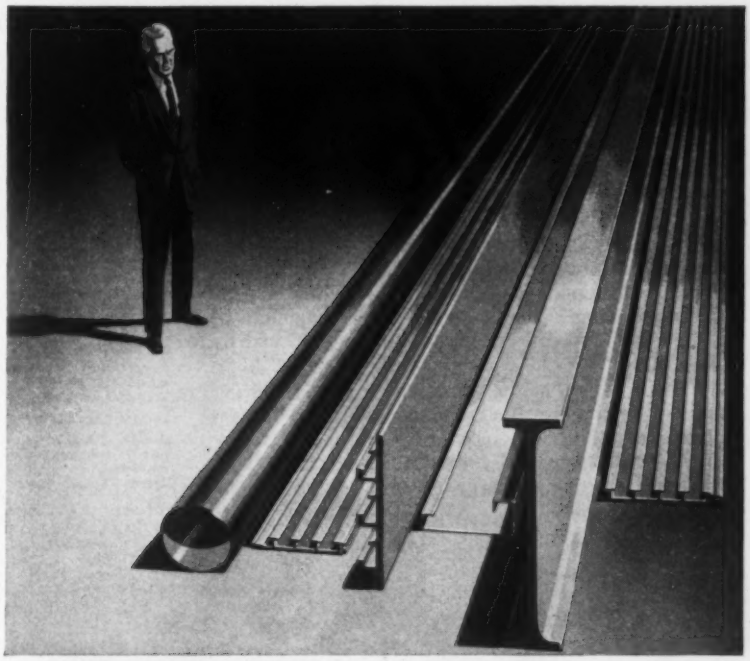
NEW ALLOY ELIMINATES STRESS RELIEF AFTER WELDING

A newly developed Dow alloy for magnesium sheet and plate, ZE10A, containing zinc and rare earth metal, does away with the need for stress relief after welding . . . particularly advantageous in building large structures. Suggested applications – large shipping and storage containers, even tank-trailer bodies. So that designers can take full advantage of this new sheet and plate material, Dow also provides magnesium extrusions in alloys requiring no post-welding stress relief.

VAST PRODUCTION FACILITIES FOR MAGNESIUM AND ALUMINUM

The Dow Metal Products Company offers a new die casting plant, a sand and permanent mold foundry, a fabrication plant plus the huge Madison plant for sheet, plate and extrusions. At Madison, for example, is the giant 13,200-ton press that extrudes king-size sections of magnesium or aluminum—up to 30 inches across and 80 feet long.

For more information about the new magnesium developments shown here, or for help in any design or fabrication problem involving magnesium or aluminum, contact the nearest Dow sales office. Or write THE DOW METAL PRODUCTS COMPANY, Midland, Michigan, Merchandising Department 1053CD11.



King-size extrusions make possible freedom in design.

DOW **THE DOW METAL PRODUCTS COMPANY**

Division of The Dow Chemical Company

For more information, turn to Reader Service card, circle No. 405

NEW DIMENSIONS IN DESIGN

NEW CONCEPTS OF ECONOMY

ACIPCO CERAM-SPUN Steel Tubing

In all types of industry, versatile Acipco centrifugally spun tubing is giving the design engineer greater freedom. Furnished with the exact combination of physical, chemical and metallurgical properties required by design, manufacturing and service conditions, high quality Acipco tubing helps create both new dimensions in design and new concepts of economy.

You can order any combination of lengths, O.D.'s and wall thicknesses because Acipco is not limited by equipment sizes. This new ceramic mold process can economically produce an infinite variety of lengths, from a minimum of 4′ to a maximum of 20′ as cast, and longer lengths can be produced by fabricating.

If you design, manufacture, or use parts requiring tubular metal stock as a component, an investigation of the versatility of Acipco tubing and the flexibility of Acipco's integrated facilities for spinning, heat treating, machining, fabricating and testing will be worth your while.

COMPLETE FACILITIES

SPINNING
Acipco Steel Tubes are centrifugally spun to exact physical and metallurgical specifications. The exact size and metal analysis your process or project requires is assured.

FABRICATION
Complete, integrated facilities for machining, welding, finishing and heat treating of tubular parts save shipping time and expense for Acipco customers.

TESTING
Facilities for both hydrostatic and air testing, as well as for other physical and chemical analyses and tests, are available as part of complete Acipco steel tube service.

INSPECTION
Expert inspection, including radiography, during all phases of production, helps keep Acipco steel tube quality high.

TECHNICAL ASSISTANCE
A staff of highly trained engineers, metallurgists, chemists and craftsmen serves the designer and manufacturer who specify Acipco Steel Tubes.

SIZE RANGES: Tubes are produced in lengths from 4′ to 20′; longer lengths can be made by welding. O.D.'s from 2.25″ to 50″—wall thicknesses from .25″ to 8″.

ANALYSES: All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steels, plain carbon steel and special non-standard analyses.

FINISHES: As cast, rough machined, or finish machined, including honing and grinding. Complete welding and machine shop facilities are available.

ACIPCO
SPECIAL PRODUCTS
DIVISION OF AMERICAN CAST IRON PIPE CO.
BIRMINGHAM 2, ALABAMA

For more information, turn to Reader Service card, circle No. 381

The seams don't show

Beautiful fit, beautiful look, beautiful soft drink dispenser. Beautiful job of close tolerance molding by General American. Working from wooden patterns, General American engineers designed six individual moldings. The shrinkage of each separate part was calculated to the thousandths of an inch. General American made the tools with the same precision.

Result—when this soft drink dispenser is assembled the seams are practically unnoticeable. In addition, the selection of the proper plastic, combined with General American's skill in molding, provides a product with very good luster, high impact properties, excellent stain resistance—and a reasonable price tag.

If you have a part or product that could or should be made of plastics, consult General American. In plastics, *it pays to plan with General American.*

in this 6-piece soft drink dispenser

GENERAL AMERICAN TRANSPORTATION CORPORATION

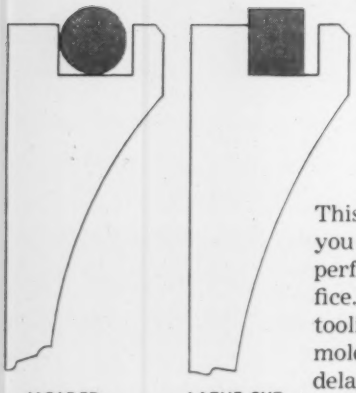
135 South LaSalle Street, Chicago 3, Illinois

Offices in principal cities

PLASTICS DIVISION GENERAL AMERICAN TRADE MARK

Why ACADIA LATHE-CUT SYNTHETIC RUBBER SEALS

can save you money in *STATIC* or *MOVING* seal applications



MOLDED O-RING SEAL

LATHE-CUT SEAL

This seal will save you money with no performance sacrifice. Minimum tooling cost, no molds, no costly delays. Can be made up to 25″ I.D.

Acadia Synthetic Rubber Parts are of the highest quality components, processed for oil resistance, good aging properties, resistance to heat. They can be furnished in any dimension or special compound you desire to precision tolerances. They are another example of Acadia's ability to SAVE YOU MORE..SERVE YOU BETTER.

There's an Acadia Sales engineer near you to serve you. Write us today, and we'll put him in touch with you immediately.

ACADIA *Synthetic* **PRODUCTS**

DIVISION OF WESTERN FELT WORKS
Dept. D, 4021-4139 West Ogden Avenue, Chicago 23
Branch Offices in Principal Cities

MANUFACTURERS AND CUTTERS OF WOOL FELT

For more information, turn to Reader Service card, circle No. 376

A DRAMATIC DEMONSTRATION OF THE NEW CLAD-REX 102 LAMINATE

Boiling water provides a positive test for two deep drawn* vinyl-clad parts. Neither special care in forming, nor post curing has been used to prepare either part.

Almost within a matter of seconds, the part formed of conventional vinyl-clad metal (at right) begins delaminating at the corners.

Even after as long as four hours of boiling, the part formed of new Clad-Rex 102 laminate (at left) still shows no delamination whatsoever.

New Clad-Rex vinyl-clad metal sharply reduces limitations in deep drawing and heat exposure

Has your interest in vinyl-clad metals been cooled because your product is deep drawn? . . . or because your product is exposed to elevated temperatures? . . .

Now, you can solve the problem with new Clad-Rex 102. It's a new vinyl-metal laminate that is, in effect, a single element of material. Clad-Rex 102 combines *for the first time* the ultimate properties of sheet metal with the optimum characteristics of vinyl.

Call or write for facts of this major technological breakthrough by the extensive research laboratories of Simoniz Company.

*Depth of draw equal to six times radius of corner

VINYL-METAL LAMINATES BY **CLAD-REX**® DIVISION OF SIMONIZ COMPANY

11514 W. King Street • Franklin Park, Illinois

Telephone: GLadstone 1-2323

22C

For more information, turn to Reader Service card, circle No. 404

TubeXperience in action

TUBING MAY LOOK ALIKE

But one is a better buy

And that is another reason why anyone concerned with the use of tubing should keep continually abreast of the materials available to him. The subject is not one that can be learned and remembered—it is being ceaselessly revised. Here at Superior, world's largest producer of small-diameter tubing, development of new materials is a program that has no end. As technology advances, so does our range of analyses.

Over 120 materials are offered. Included are analyses that have been modified in order to meet changing requirements and more exotic service conditions. In the selection of the right material from our big array can lie your opportunity to meet challenging problems of design or to enhance the performance of your applications already devised—perhaps even lower your unit cost through longer service life.

We also offer you excellent service through a network of knowledgeable distributors coast to coast. And you can freely call on us, in complete confidence, if you have some tough problem and wish to share its complexities. For interesting particulars, send for a copy of our Bulletin 42. Superior Tube Company, 2006 Germantown Ave., Norristown, Pa.

AMONG OUR NEWER MATERIALS

Grades putting the little-used metals to service

Zircaloy-4. An alloy of zirconium, tin, iron, and chromium. Essentially like Zircaloy-2 except for the absence of nickel, it is less subject to hydrogen embrittlement. For this reason, this new zirconium alloy is being investigated for use as fuel element cladding in nuclear reactors, its principal application thus far.

Columbium Alloy with 1% Zirconium. This is one of several columbium alloys with which we are experimenting. Already it is being used to replace the unalloyed metal as fuel element cladding in nuclear reactors because it is twice as strong at elevated temperatures. It is a soft, ductile alloy, easily welded or fabricated. In certain applications its corrosion resistance is superior to that of unalloyed columbium.

Tantalum. We have been drawing tantalum tubing since 1945. The higher purity grades now produced permit new possibilities to be foreseen where weight is not a factor (0.60 lb/cu in.). It has a high melting point: 5425°F. Of significance is its excellent resistance to acids. It is easily cold-worked and weldable to itself. One of the growing applications for tantalum tubing has been for thermocouple sheathing where its outstanding corrosion resistance can be used to excellent advantage.

Beryllium. Pure beryllium tubing drawn and sized in the hot condition has wide use in the nuclear and aircraft/missiles industries because of its combination of characteristics, such as low neutron absorption, desirable thermal properties, and high strength-to-weight ratio.

Send for technical bulletins on the above

PUT THE "SUPER ALLOYS" TO WORK FOR YOU

Alloys for high-temperature strength

In 1948 and again in 1957 we published data on "Super Alloy" tubing. Within the last three years we have been able to accumulate a vast amount of additional information on the subject. We present it in detail in our Bulletin 71, just off the press. Covered are eight of the "Super Alloys," those which have attracted the most interest and apparently have the greatest potential for usefulness. We want you to have a copy—drop us a line.

STANDARD AND SPECIAL SUPERIOR TUBING MATERIALS

Standard		Special
Stainless		**Stainless**
303	321 Super Pressure	317
304	347	D319
304 Hydraulic Qual.	347 Hydraulic Qual.	330
304 Super Pressure	347 Super Pressure	405
304L	348	416
305	403 Mod.	17-7PH[2]
309	410	N-155[3]
310	420	19-9DL[4]
316	430	PHI5-7 Mo[2]
316 Super Pressure	430 Ti	
316L	446	
321	502	
321 Hydraulic Qual.	A-286[1]	
Nickel and Nickel Alloys		**Nickel and Nickel Alloys**
Low Carbon Nickel[5]	Inconel X[5]	D Nickel[5]
A Nickel[5]	Ni-Span C[5]	DURANickel[5]
Monel[5]	Hastelloy C[6]	Nionel[5]
403 Monel[5]	Hastelloy X[6]	Inconel 702[5]
K Monel[5]	Haynes 25[6]	Hastelloy F[6]
R Monel[5]	80% Ni-20% Cr Alloy	Permalloy[7]
Inconel[5]	Invar	Waspalloy
Copper Base Alloys		**Copper Base Alloy**
30% Cupronickel	OFHC Copper	Berylco # 10[8]
Beryllium Copper	Deoxidized Copper	
Constantan		
Reactive Metal		**Reactive Metals**
Unalloyed Titanium A-40		Zirconium
		Zircaloy-2
		Zircaloy-3
		Zircaloy-4
		Columbium
		Tantalum
		Vanadium
Carbon Steels		
C-1008	MT-1020	
C-1008 Diesel	C-1025	
MT-1010	C-1035	
MT-1015	C-1045	
Leaded C-1020	E-1095	
Ingot Iron		
Alloy Steels		
4130	4140	
4130 Bourdon	4150	
4130 Super Pressure	4615 Diesel	
4132	8630	
52100		
Glass Sealing Alloys		
(446) 27% Chrome	Sylvania # 4[9]	
42% Nickel-Iron	Rodar[10]	
52% Nickel-Iron	Kovar [11]	
Therlo[12]		

Registered Trademarks

[1]Allegheny Ludlum Steel Corp.
[2]Armco Steel Corp.
[3]Union Carbide Corp.
[4]Universal Cyclops Steel Corp.
[5]International Nickel Co.
[6]Haynes Stellite Co.
[7]Western Electric
[8]Beryllium Corp.
[9]Sylvania Electric Products, Inc.
[10]Wilbur B. Driver Co.
[11]Stocked and sold through the Stupakoff Div. of the Carborundum Co., Latrobe, Pa., TM Reg. U.S. Patent Office, Westinghouse Electric Corp.
[12]Driver-Harris Co.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to 5/8 in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

For more information, turn to Reader Service card, circle No. 469

IPC has a new baby!

I.P.C.'s extensive research in the area of fluorocarbon plastics has given birth to *a whole new series of custom seals, ball seats, diaphragms, V, cup and flange packings.*

Designated as the F-C series, these thoroughly tested components are literally a blend of I.P.C. synthetic rubbers and fluorocarbon plastics. This unique combination produces seals and packings with *lower friction, less torque, better corrosion resistance and reduced shaft wear.*

You can handle increased pressures . . . higher shaft speeds *and* most high temperature applications with F-C seals and packings. Special molding machinery and techniques have been developed by I.P.C. to produce this combination. Synthetic rubber, fluorocarbon plastics and steel cases are brought together in one operation to provide the last word in high quality case seals.

There's good reason to look at the newest member of I.P.C.'s custom family *in terms of your sealing problems. Do it soon; Won't you?*

IPC

OIL SEALS
PACKINGS
PRECISION MOLDING
Custom designed for your application.

INTERNATIONAL PACKINGS CORPORATION

Bristol, New Hampshire

© IPC

P4

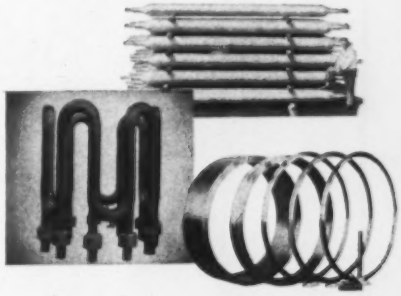
For more information, turn to Reader Service card, circle No. 432

COMPLETE HIGH ALLOY CASTING SERVICE

CENTRIFUGAL CASTINGS • STATIC CASTINGS • SHELL MOLDED CASTINGS

resisting corrosion, high temperatures, abrasion

CENTRIFUGAL CASTINGS

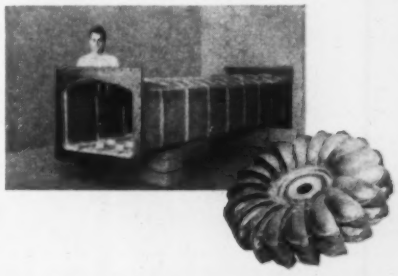


Because of the specially desirable characteristics imparted to the metal in a centrifugal casting, this type is showing up more and more in design and purchase specifications. Each casting must have a straight concentric bore, the diameter of which is controllable.

The important point to remember about centrifugal castings is that the metal is exceptionally uniform in structure and dense, brought about partly because metal molds are used which produce an increased chilling effect and improved density. The centrifugal force practically eliminates the possibility of blow holes or gas pockets. In fact, this same force gives much the same effect on the casting that is obtained when forging or working a bar or ingot.

Outside diameters from 2½" to 32", lengths generally 24" to 180".

STATIC CASTINGS

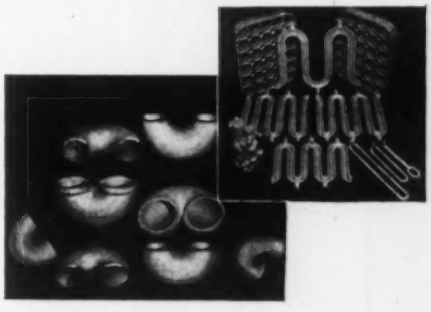


These are the so-called conventional type of castings, utilizing stationary sand molds. With our large battery of electric furnaces, we can operate with considerable flexibility. We have very small furnaces permitting us to cast economically just a "few" small lightweight pieces. Or we can combine our melting capacities to produce a single heavy tonnage piece. With all available furnaces working, we can carry on a variety of melts simultaneously.

Static castings can be produced in weights ranging from a few ounces to single castings 7 tons and heavier; wide range of alloying combinations, including the new HOM.*

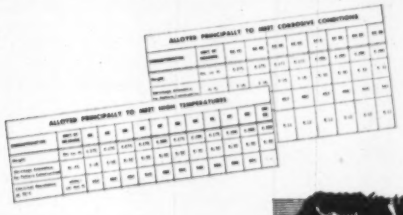
*Covered by U.S. Patents

SHELL MOLDED CASTINGS



For several years now we have been producing in steadily increasing tonnages a great variety of high alloy castings by the shell molded method.

Shell molded castings can be made very economically when smaller pieces on a mass production basis are involved. The weight of the individual piece can range from an ounce or two to several pounds. The major advantage in a shell molded casting over other types of casting is in the exceptionally close adherence to design dimensions plus usually a much superior surface. Subsequent machining of the part is practically eliminated. From the design point of view, the shell molded piece can be cast in more intricate design and with thinner sections than when conventional castings are used.



If the casting used in your equipment has to meet high temperature (anything up to 2300°F) and/or corrosion, why not discuss your requirements with our metallurgical staff? Our company can call upon more than 35 years of experience in this exacting business of high alloy castings. In the meanwhile, if you would like to have a copy of our latest catalog, write or call our nearest office for Catalog No. G-159.

ALLOY CASTING INSTITUTE ACI MEMBER

The DURALOY Company

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EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
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DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

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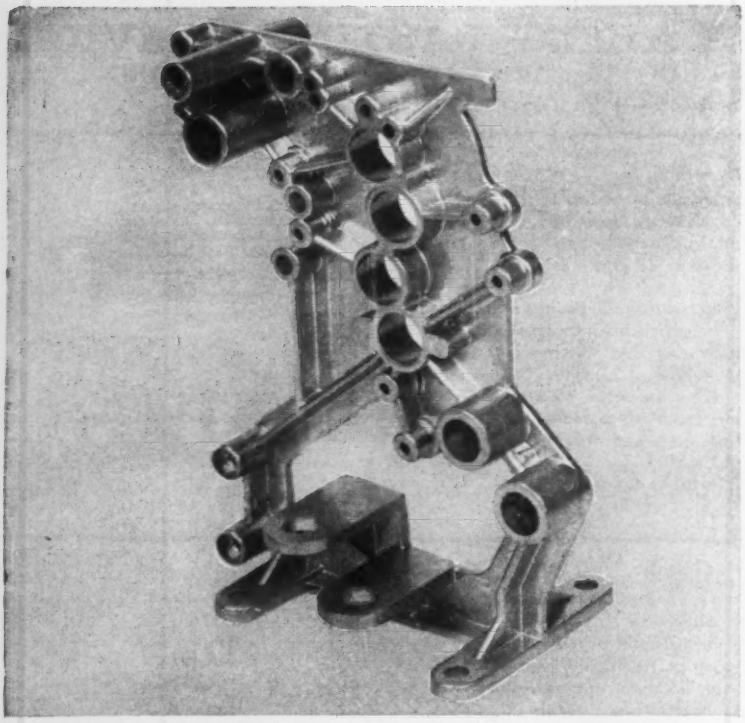

What other process could do it so well?

All things considered, there's really only one *best* way to produce this typical die casting application.

When you figure that it must be built at the lowest possible unit cost, must use a production method that is highly flexible to accommodate the unusual shape, and must maintain a variety of close tolerances . . . only die casting *could* do the job.

Working closely with Twin City engineers, this manufacturer *designed* for die casting to get the maximum out of the process. By thinking in terms of die casting right from the drawing boards he eliminated many production and finishing jobs, saved on unit costs, saved on machining.

Possibly you're producing a part by some more costly, less flexible, less accurate process than die casting. If you think that might be true, contact Twin City Die Castings Company. Twin City engineers can probably save you money. They have for hundreds of customers.

. . . only DIE CASTING can
✓ cut your costs
✓ offer such flexibility
✓ provide such accuracy

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producing custom-made parts, seals and components of natural, synthetic and silicone rubber compounds. **212**

Perforated Metal Sheets. Harrington & King Perforating Co., Inc., 6 pp, illus. Sizes, gages and materials of perforated metal sheets carried in stock. **214**

Fabricated Silicone Rubber. Haveg Industries, Taunton Div., 6 pp, illus. Information on silicone rubber seals for the aircraft, electronic and appliance industries; precision molded parts; extruded parts; and die cut parts. **215**

Sponge Iron. Hoeganaes Sponge Iron Corp., 20 pp, illus. Tells what sponge iron is, traces its origin, outlines its properties, characteristics, and use in quality steel. **216**

Beryllium Copper Parts. Instrument Specialties Co., Inc., 20 pp, illus., No. 10. Design information, properties and uses of beryllium copper springs and screw machine products. **217**

Aluminum Extrusions. Jarl Extrusions, Inc. Information on producing and anodizing alumi-extrusions. **218**

Aluminum Hand Forgings. Kaiser Aluminum & Chemical Sales, Inc., 20 pp, illus. Alloys and tempers, heat treatment, property guarantees, specifications and tolerances of aluminum hand forgings. **219**

Custom Forgings. Lenape Hydraulic Pressing and Forging Co., 108 pp, illus., general catalog. Information on services and facilities available for custom forging of pressure vessel connections and manways. Included is a price list. **220**

Reinforced Plastics Moldings. G. B. Lewis Co., 24 pp, illus. Information on properties, tests, design, tools and dies, molding methods, fabrication and assembly, finishing and painting, and other data on reinforced plastics molding. **221**

Specially Shaped Wire. Little Falls Alloys, Inc., 4 pp, illus. Properties, specifications and available alloys in which specially shaped round, flat, square and rectangular wire is available. **222**

Meehanite Castings. Meehanite Metal Corp., 4 pp, illus., No. 32. Physical, mechanical, and thermal properties of general and heat resisting Meehanite metal castings. **223**

Porous Metal Components. Mott Metallurgical Corp., 4 pp, illus. Information on controlled porosity stainless steel used for precision components. **225**

Silicone Rubber. Moxness Products, Inc., 4 pp, No. 310. Properties of low compression set, general purpose, high strength, fuel and oil resistant, high temperature and

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New Design Opportunities Through Aluminum Forgings

STEEL CONNECTING ROD ASSEMBLY

ALUMINUM CONNECTING ROD ASSEMBLY

Both of these connecting rods were designed for use in the same automotive air conditioning compressor.

WHICH CONNECTING ROD COSTS LESS?

One glance tells you it's the aluminum connecting rod at the right. Two pieces are easier and less expensive to fabricate than five.

By designing this connecting rod as a Kaiser Aluminum forging, Lennox Tool & Machine Builders of Lima, Ohio, cut costs for their customer, Airtemp Division, Chrysler Corporation.

The steel connecting rod formerly used required five different pieces, including three bronze inserts for wrist pin and crankshaft bearings, plus two connecting rod bolts. Plenty of precision machining was also required.

The new aluminum connecting rod consists of only two pieces, plus the two connecting rod bolts. For this part, the forging itself was bored to provide a hard mirror-finish surface for wrist pin and crankshaft bearings, thus eliminating the three bronze inserts.

Strength? The aluminum forging meets every strength and dimensional stability requirement specified for the compressor application. In fact, the life expectancy of forged aluminum rods and steel rods with bronze insert is virtually the same!

This is another example of how strong, lightweight Kaiser Aluminum forgings can simplify design and cut material, machining and assembly costs. To find out how Kaiser Aluminum forgings can save you money, mail the coupon now!

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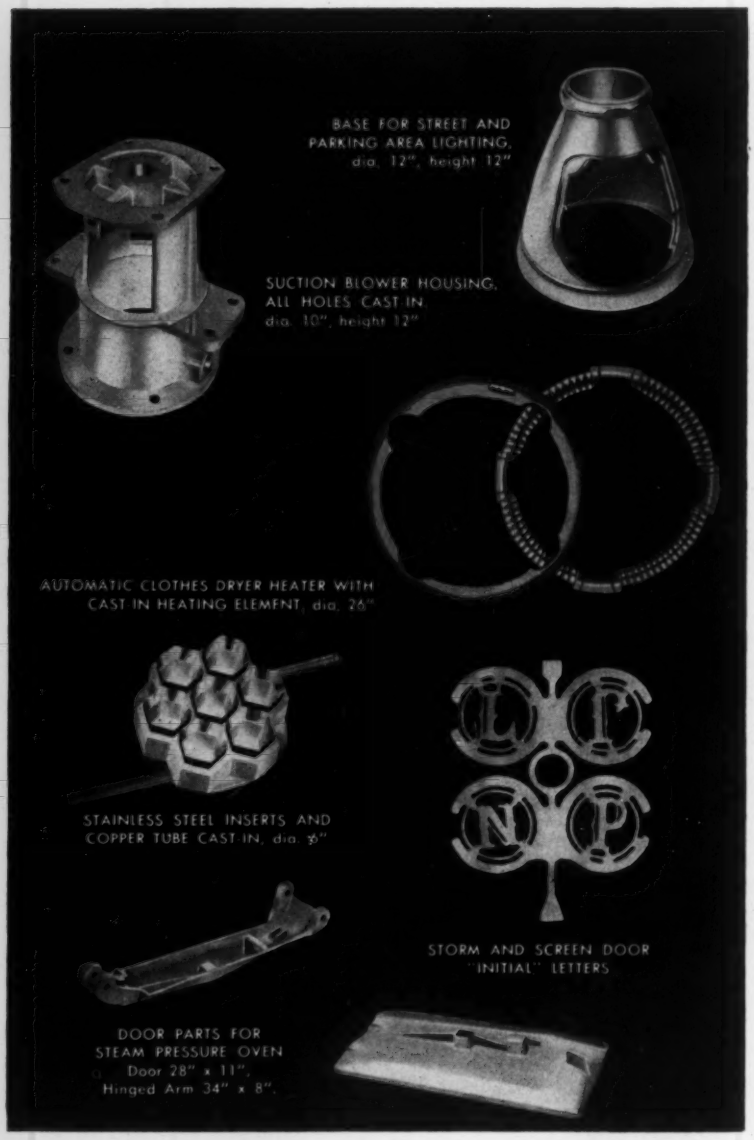

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The method of casting that assures density, homogeneous structure, with surfaces that take a high finish. Illustrated castings indicate how other metals are cast with aluminum to meet specific performances. For more ideas and recommended applications, write for new brochure. Our permanent mold engineers will be happy to work with you.

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NEWS FOR MATERIAL DESIGN ENGINEERS

Here... from one source... are two new developments of signal importance to design engineers in all industries.

ALNICUS®

a high energy permanent magnet material developed by the Magnetic Materials Division of U. S. Magnet & Alloy Corporation – now makes it possible to custom design magnetic devices in virtually any size and shape with the highest magnetic power ever achieved.

ALNICUS 75®, with its nominal energy product of more than 7.5 million gauss-oersteds, broadens the scope of magnet applications. For example – with commercially produced ALNICUS 75® it is now possible to have increased magnetic energy with no increase in unit size or weight... or, retain the same high magnetic energy with a lighter, smaller unit! More important... ALNICUS 75® can be cast into virtually any size or shape... because it maintains its high magnetic power in all configurations.

ZEMO®

an entirely new and exclusive development for making precise high alloy castings in a way that provides for closer tolerances in high quality steel.

Developed by USMAC... Steel Castings Division of U. S. Magnet & Alloy Corporation... ZEMO high integrity steel castings are actually lower in overall cost – yet, of the highest quality. Zemo castings, produced in USMAC's modern, high efficiency plant are delivered in a condition which precludes a number of expensive finishing operations. Thus, because there is considerably less finishing and machining required – **you save both time and money.**

If you are involved in material or product design you will be interested in the following brochures:

ALNICUS® Brochure #12 – address Magnetic Materials Division

ZEMO® Brochure #11 – address USMAC Steel Castings Division

U. S. MAGNET & ALLOY CORP.
266 Glenwood Avenue
Bloomfield, New Jersey

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From National-Standard . . .

SPECIALTY WIRE and Metal Products

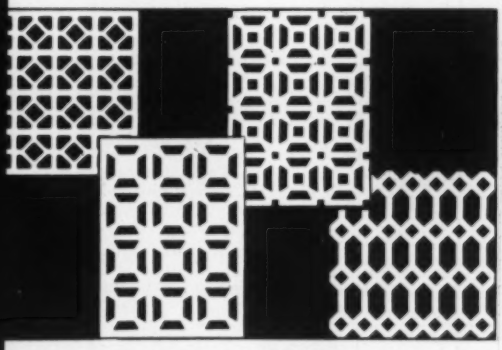
Whatever your product, if it requires high-quality, specialty wire, wire cloth, flat spring steel or perforated metal, National-Standard Company's specialized manufacturing and engineering services are important to you.

FOR OVER 50 YEARS National-Standard has been a leader in the development of special wire and metal products for special applications, with emphasis on alloys, finishes, corrosion resistance, strength, elongation and adhesion properties. And today, National-Standard maintains leadership through the constant development of new materials, new techniques, new services, plus precise control and meticulous care in manufacturing to the most exacting specifications.

EXPERIENCED ENGINEERING help for jobs requiring specialty steel and wire to meet unique applications is available to you from National-Standard. Write for additional information to National-Standard Company, Niles, Michigan.

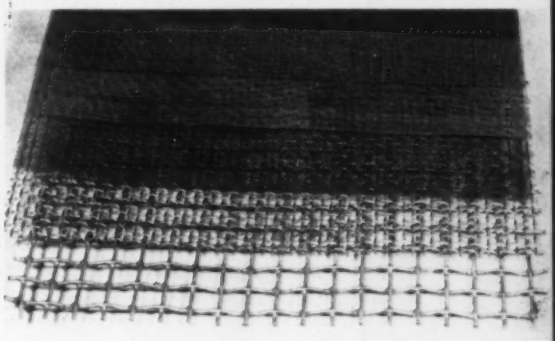
SPECIALTY WIRE is engineered for the most difficult applications by National-Standard. Just a few of the many specialties are: drawn wire in fine sizes of stainless and high carbon steel; electro-coated steel wire with nickel, copper, brass and other coatings; a wide variety of finishes such as bright, galvanized, liquor, tin, bronze, etc.; music spring wire; special-purpose wire strand and flat and tubular braid in steel and other metals; and high-temperature alloy wires such as Inconel-X, NS-25 (L605), NS-A286, René 41, NS-1000.

HIGH-CARBON SPRING STEEL from National-Standard's Athenia Steel Division is produced with a wide variety of tempers, finishes, colors, tolerances and forming characteristics to fit your special requirements. Athenia products include flat steels in widths up to 6½" tempered and 16" cold rolled or annealed with thicknesses from .001 to .060 depending on width.



PERFORATED METAL from the Cross Perforated Metals plant of National-Standard is a quality product of clean-walled, burr-free steel or aluminum. The complete line of Cross perforated metal designs fills the requirements of hundreds of products where beauty and style must be combined with rugged functional utility.

INDUSTRIAL WIRE CLOTH from the Reynolds Wire Division can be provided in standard or special weaves in a complete range of meshes, metals, alloys and coatings in all normally required widths. Reynolds Wire Cloth is woven in widths from 24 to 48 inches, but special widths under 24 or over 48 can be supplied on request.



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NATIONAL-STANDARD COMPANY

Niles, Michigan

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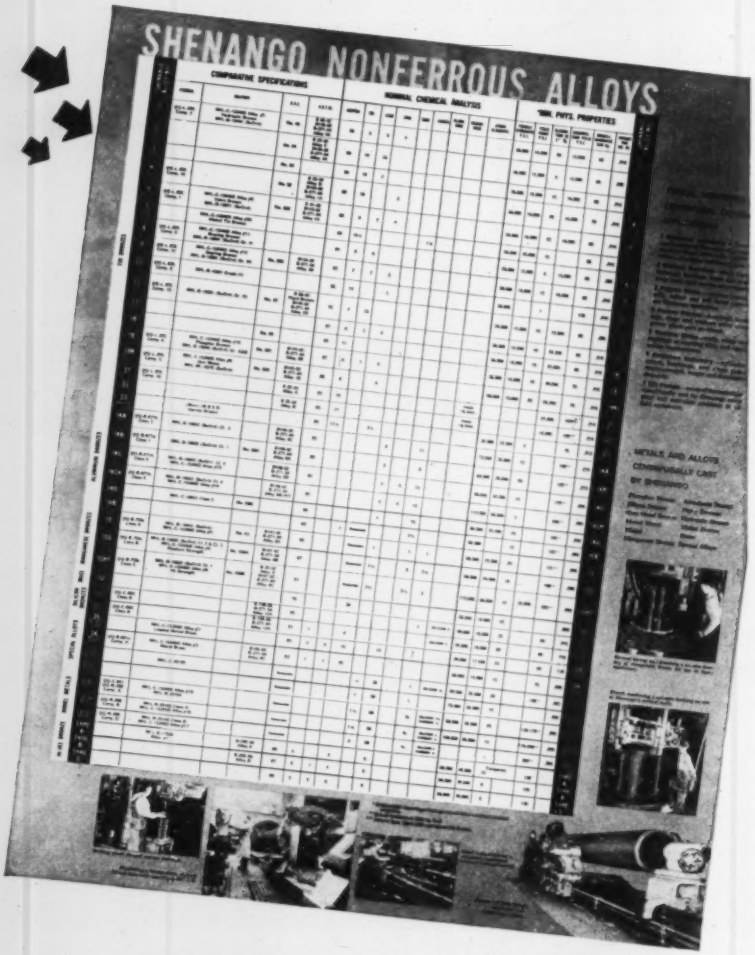

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low temperature silicone rubber compounds. **226**

Impact Extrusions. Mueller Brass Co. Mechanical properties and dimensional tolerances of round, rectangular and square impact extrusions. **227**

Zirconium Metal Parts. Zirconium Metals Corp. of America, Div. of National Lead Co., 5 pp. Composition, corrosion resistance, mechanical properties, machinability and uses of reactor and commercial grades of zirconium metal parts. **228**

Superalloy Wire. National-Standard Co., 6 pp. Series of charts give engineering data on ten superalloy wire materials. **229**

Wire Cloth. Newark Wire Cloth Co., 4 pp, illus. How to select, use and check various grades and types of wire cloth. **230**

Metal Powder Part Design. New Jersey Zinc Co., 24 pp, illus. General information on the powder metal process and its current uses. Covered are compositions and properties of nonferrous alloys, commercial tolerances, practical design suggestions and costs. **231**

Perforated Rubber, Fabrics. Perforating Industries, Inc., 16 pp, illus., No. 57. Information on perforating, slitting and blanking of various nonmetallic materials. **232**

Plastics-Impregnated Wood. Permali Inc., 6 pp, illus. Dimensional data, uses, and mechanical, physical and electrical properties of laminated thin wood veneers that are impregnated under vacuum with a special synthetic resin. **233**

Aluminum Extrusions. Precision Extrusions, Inc., 12 pp, illus., No. 5909. Mechanical properties, standard tolerances, pricing factors, and recommended uses of aluminum extruding alloys. **234**

Molded Plastics. Pyramid Products Inc., 4 pp, illus. Facilities available for custom injection molding. **235**

Iron Powders. Pyron Corp., 8 pp, illus. Chemical and physical properties, and composition of hydrogen-reduced iron powders. **236**

Metal Stampings. Reichert Float & Mfg. Co. Information on new processes and equipment used to form and deep draw intricate light and heavy metal stampings. **237**

Forgings. Rhode Island Tool Co., 26 pp, illus., No. 75. Dimensions, properties, prices and uses for drop and upset forgings, eye and special bolts, studs, cap screws, and nuts. **238**

Metal Stampings. Rockwell-Standard Corp., Stamping Div., 8 pp, illus. Describes facilities for producing stampings and assemblies in any metal or alloy. **239**

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in
forgings...

d'ARAZIEN

Alcoa puts the metal where you want it

More than a hundred tons of Douglas DC-8 kiss the runway on forged aluminum wheels like this one. Strength and lightness are obvious requirements. Even more essential is reliability through landing and after landing to guard the safety of passengers and crew.

Logically enough, rugged aluminum forgings were elected for the job. Then came many hours of Alcoa skill in die design, demonstrated in the remarkable zebra stripes visible in the cross section. They represent the aluminum grain flow* and illustrate how the tough aluminum grain is forged to withstand the shock loads of landing impact, plus the cyclic fatigue of rotation, all with a wide margin of safety.

Alcoa forges these wheels with a unique combination of blocker and finishing dies to put the metal exactly where it's needed. Alcoa Alloy 2014-T6 assures excellent machinability for the designer and producer, Bendix Products Division, Bendix Aviation Corporation. And Alcoa's forging plants, with hydraulic press capacities up to 50,000 tons, provide on-the-nose deliveries.

Think of Alcoa® Forgings when strength and lightness are rigid design requirements. Producing a complete line of forgings, Alcoa forges more large and complex shapes than any other supplier. Aluminum Company of America, 919 Alcoa Building, Pittsburgh 19, Pennsylvania.

**The patterns shown in the illustration were produced in Alcoa's Research Laboratories as part of a study of grain flow developed by the dies used to forge the DC-8 wheel.*

Alcoa puts the metal where you want it—in castings, forgings, impacts, extrusions and screw machine parts.

ALCOA ALUMINUM

For exciting drama watch "Alcoa Presents" every Tuesday, ABC-TV, and the Emmy Award winning "Alcoa Theatre" alternate Mondays, NBC-TV

Your Guide to the Best in Aluminum Value

in impacts...

Alcoa puts the metal where you want it

How BIG an impact have you seen lately? Alcoa can now make them up to 12 in. in diameter and 60 in. long.

When Alcoa's new 2,500-ton press hits an aluminum alloy slug, a giant impact is formed with the combined strength of an extrusion and forging.

Like their small brothers, these big new impacts can save you money. They are produced in one fast operation. There's no parting line to be ground. No scale to be removed. No draft to be cut off. Impacts have forged bases and extruded sections. Multiple parts can often be combined into one integral impact eliminating welded or mechanical joints. Machining is reduced, and excessive material waste is eliminated.

You can get these big new Alcoa® Impacts in many alloys with tensile strengths up to 75,000 psi. Also made from aluminum powder metallurgy alloys which provide excellent properties at elevated temperatures.

Alcoa Impacts are unfailingly sound. They have smooth, corrosion-resistant surfaces. You can have them in plain or complex shapes with design features combining those of forgings and extrusions—flanges, steps, multiple walls, bosses, ribs.

In impacts, as well as forgings, castings, extrusions and screw machine parts . . . Alcoa puts the metal where you want it. A call to Alcoa can mean ingenious design solutions. Start now; write for *Metal in Motion*, Alcoa's new 34-page brochure on impacts. Aluminum Company of America, 909-L Alcoa Building, Pittsburgh 19, Pa.

ALCOA ALUMINUM

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Alcoa puts the metal where you want it . . . in impacts, castings, forgings, extrusions and screw machine parts.

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KEEP AHEAD WITH HAVEG
PRECISION PLASTIC MOLDINGS

BECAUSE...

Only Haveg offers such versatile and complete precision plastic molding facilities, technical "know how" and experience.

Haveg works with every known molding material to provide the most economical moldings... with properties necessary to meet the most rigid specifications.

Today Haveg is literally making design dreams come true... through its extensive research and development laboratory facilities as well as the best quality control laboratory within the industry.

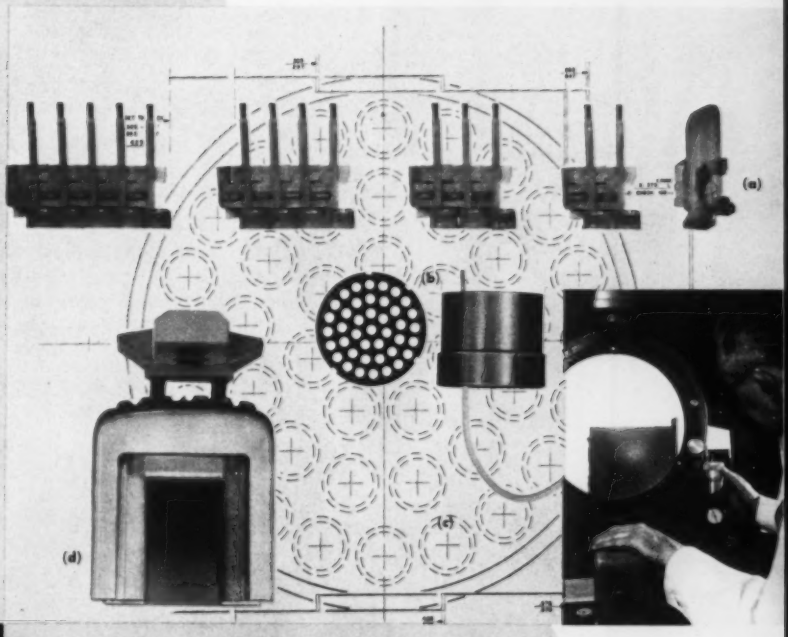
Shown in photo are:

(a) **A series of crab locks molded from nylon.**

(b) **Electrical connectors for making and breaking as many as 41 electrical circuits at one time are used in missile tracking equipment.**

(c) **Comparator chart in background enlarges connectors 10 times and checks the accuracy of all holes and insets.**

(d) **Pick-up head for stereophonic record player. This is a complicated but very small part in which three insets are molded into the head.**



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FIRST IN *Engineered* PLASTICS

CUSTOM ENGINEERED FABRICATED SILICONE RUBBER

Many highly specialized procedures are essential to produce the superior quality so closely identified with Haveg. Expert tool design and construction, rigid process control and complete testing facilities are but a few of the vital operations in Haveg's quality assurance program. The Haveg engineered parts shown here are being used with great success in aircraft, missile, electronic, appliance and other applications because of these important features.

1. **High Temperatures—up to +600°F.**
2. **Low Temperatures—down to −150°F.**
3. **Excellent Electrical Properties at High Temperatures.**
4. **Low Compression Set Characteristics.**
5. **Long Life—unaffected by weather and ozone.**
6. **Wide Choice of Colors.**

Haveg formulations maintain their physical and chemical characteristics under the most adverse conditions. By combining with use-proven reinforcing agents—Dacron*, Teflon* and Fiber Glass, Haveg can develop for the user a particular property, or a multiplicity of properties, such as strength, low coefficient of friction, maximum resistance to fuel, oil, chemicals and heat.

Strict adherence to the highest of standards of quality control permits Haveg to guarantee the quality of every shipment of Fabricated Silicone Rubber.

For further information, or any of Haveg's products and facilities, write, wire or phone—our engineers will be glad to work closely with you. All transactions will of course be confidential.

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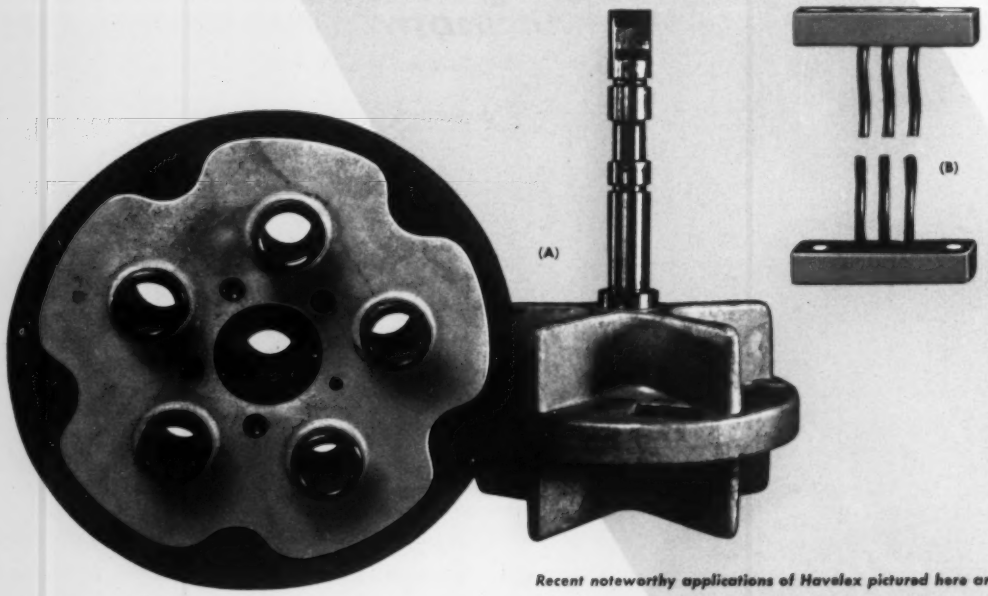
HAVELEX®

(formerly G. E. Mycalex)

Haveg's Precision Molded Rigid Inorganic Insulation Material offers all these unique advantages

- **Dimensional Stability**
- **1000°F Continuous Temperature Resistance**
- **Dielectric Strength**
- **Mechanical Strength**
- **Low Loss Factor**
- **Low Power Factor**
- **Arc Resistance**
- **No Moisture Absorption**

Havelex is composed of special glass reinforced with mica. Grey to white in color, this dense stone-like material provides an ideal insulator for wide ranges of ambient operating conditions and electrical stresses. The unusual combination of properties in Havelex plus Haveg's ability to provide precision molded tolerances and intricate shapes permit unlimited design possibilities. Complex metal inserts can be permanently molded in position, facilitating component assembly and assuring end product reliability.



Recent noteworthy applications of Havelex pictured here are:

(A) Disconnect Assembly nearly 5 inches in diameter with massive insets—Havelex provides the electrical insulating "heart" of this disconnect device used in "on the ground" service to military jet aircraft. If for any reason the power disconnection is made while the aircraft is drawing its electrical power from the airport installation, an instantaneous disconnection is insured by this device; hence, protection against personal injury or equipment damage.

(B) Transistor Test Socket—three stainless Steel tubes (.010" wall) integrally molded into Havelex body. A key component in reliability testing of transistors in high ambient temperatures.

(C) Ionizer Component—air filter unit for home heating system.

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Custom Compression and Transfer Molding
Custom Automatic Molding
Custom Injection Molding
Custom Specialty Molding (Polyesters and Diallyl Phthalates)
Sealing Caps and Tubes
Custom Fabricated Silicone Rubber
Custom Havelex Molding (formerly G. E. Mycalex)
Complete Mold Making Facilities

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for unlimited cylindrical applications

Do the products pictured here spur your imagination? These are typical of the cylindrical products we are casting centrifugally and machining to precise requirements for many prominent manufacturers and military branches. Write for: Sandusky Centrifugal Castings Bulletin #200. Contains application data and specifications on more than 70 ferrous and non-ferrous alloys in a range of properties that is a designer's dream.

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SANDUSKY QUALITY
CENTRIFUGAL CASTINGS

TYPES: Rolls, Sleeves, Rings, Bearings, Bushings, Liners, Bands, Drums, Cylinders, Tubes, Shells, Retorts, Pressure Vessels, Pressure Piping.

SIZES: From 7" to 54" O.D. —lengths up to 33 feet.

MATERIALS: Stainless, Carbon and Low Alloy Steels; full range of Copper-Base and Nickel-Base Alloys.

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High-temperature insulation for missile components is a major space-age problem... and a Dumont specialty. Polaris and Minuteman already testify to the experienced skills of Dumont in high-pressure molding of reinforced plastics. Characteristic of Dumont's ability to meet new challenges with new solutions is the development of the first tactical lightweight plastic exhaust nozzle to combine structural and insulating components into a single assembly. The future of missile flight is dependent upon thermal insulating requirements of rocket motors, nose cones, re-entry vehicles. Dumont's advanced techniques of high-pressure compression and autoclave molding, supported by process and materials development, are already prepared to meet those requirements.

Dumont's experience and technology in the field of high-temperature insulation and sandwich structures are available through its technical service staff. Learn how Dumont's facilities and abilities can help you find insulation answers. Write today for Brochure D.

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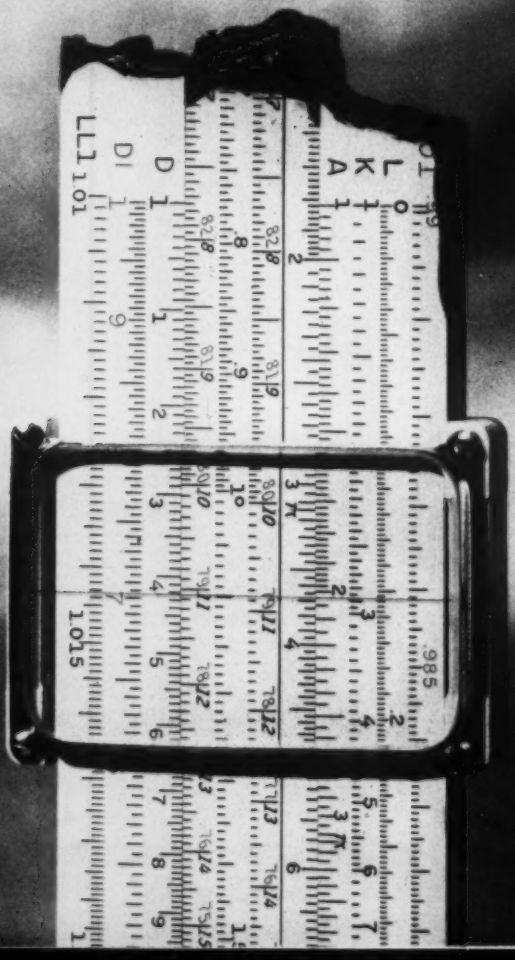

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Centrifugal Castings. Sandusky Foundry & Machine Co., 16 pp, illus. Tells how centrifugal castings are made, and shows the use of these castings in unfired pressure vessels and nuclear equipment. **240**

Nonferrous Centrifugal Castings. Centrifugally Cast Products Div., Shenango Furnace Co., 8 pp, illus., No. 157. Specifications, chemical composition and physical properties of nonferrous alloys used in centrifugal castings. Shows parts and assemblies produced by the centrifugal method. **241**

Vinyl-Metal Laminates. Clad Rex Div., Simoniz Co., 8 pp, illus. Gives physical, chemical and thermal properties, and abrasion resistance of vinyl-metal laminates. **242**

Small Tubing. Superior Tube Co., 12 pp, No. 42. Series of charts give information on how to select tubing for a specific application. Covered are 84 grades of carbon, stainless, and alloy steels; nickel and nickel alloys; copper-base alloys; glass sealing alloys; and reactive metals. **243**

Clad Metals. Texas Instruments, Inc., Metals & Controls Div., 10 pp, illus., No. GP-1A. Characteristics, types, and uses of clad metal thermostats and electrical contacts. **244**

Precision Die Castings. Twin City Die Castings Co., 14 pp, illus. Facilities for making precision die castings from zinc, aluminum and lead-base alloys. **245**

Steel Castings. Unitcast Corp., illus., No. 649A. Testing facilities for insuring high quality production of steel castings. **246**

Precision Steel Castings. USMAC Steel Castings Div., U. S. Magnet & Alloy Corp., 4 pp, illus. Information on a process for manufacturing high integrity, close tolerance steel castings. The process replaces some sand casting methods and is said to eliminate many expensive and time consuming finishing operations. **247**

Stainless Steel Castings. Waukesha Foundry Co., Castings Div., 8 pp, illus., No. SS. Physical properties and uses of martensitic, ferritic and austenitic stainless steel castings. **248**

Aluminum Extrusions. R. D. Werner Co., Inc., 4 pp, illus. Sizes and uses of aluminum extruded and roll formed shapes. **249**

Synthetic Rubber Products. Western Felt Works, Acadia Div., 6 pp, illus. Shows various types of molded, extruded, die cut and lathe cut synthetic rubber parts. **250**

Plastics Extrusions. Yardley Plastics Co., 4 pp, illus. Facilities for producing extruded plastics parts including profile extrusions, gaskets and tubing. **251**

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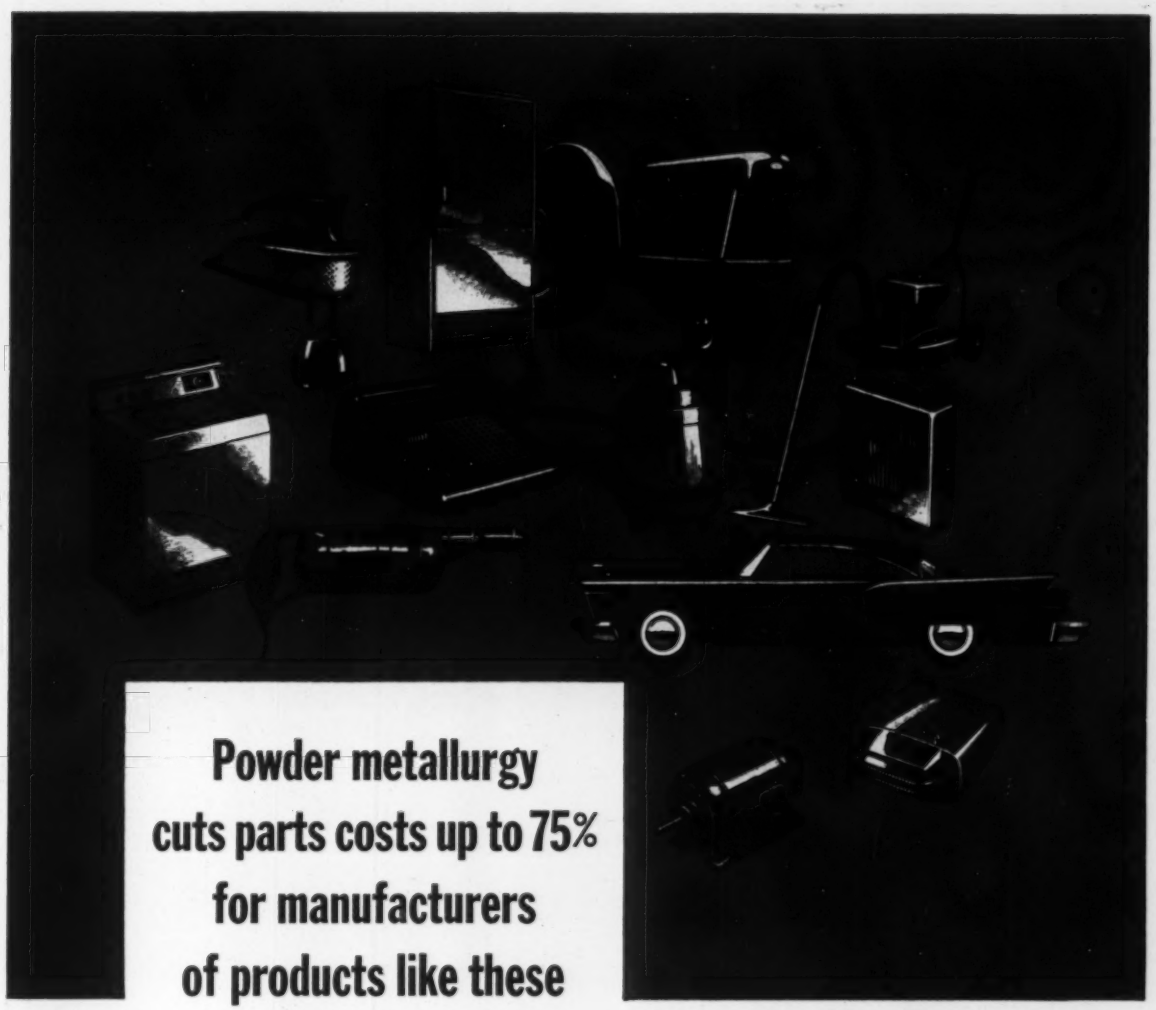

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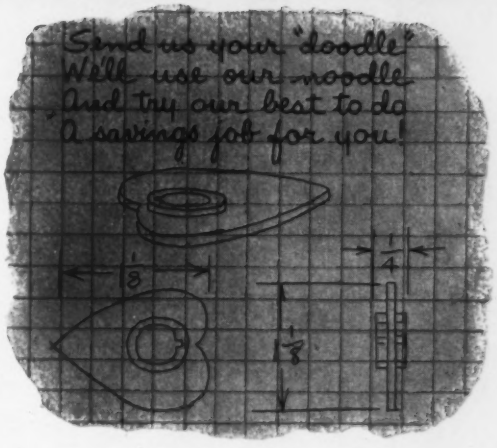

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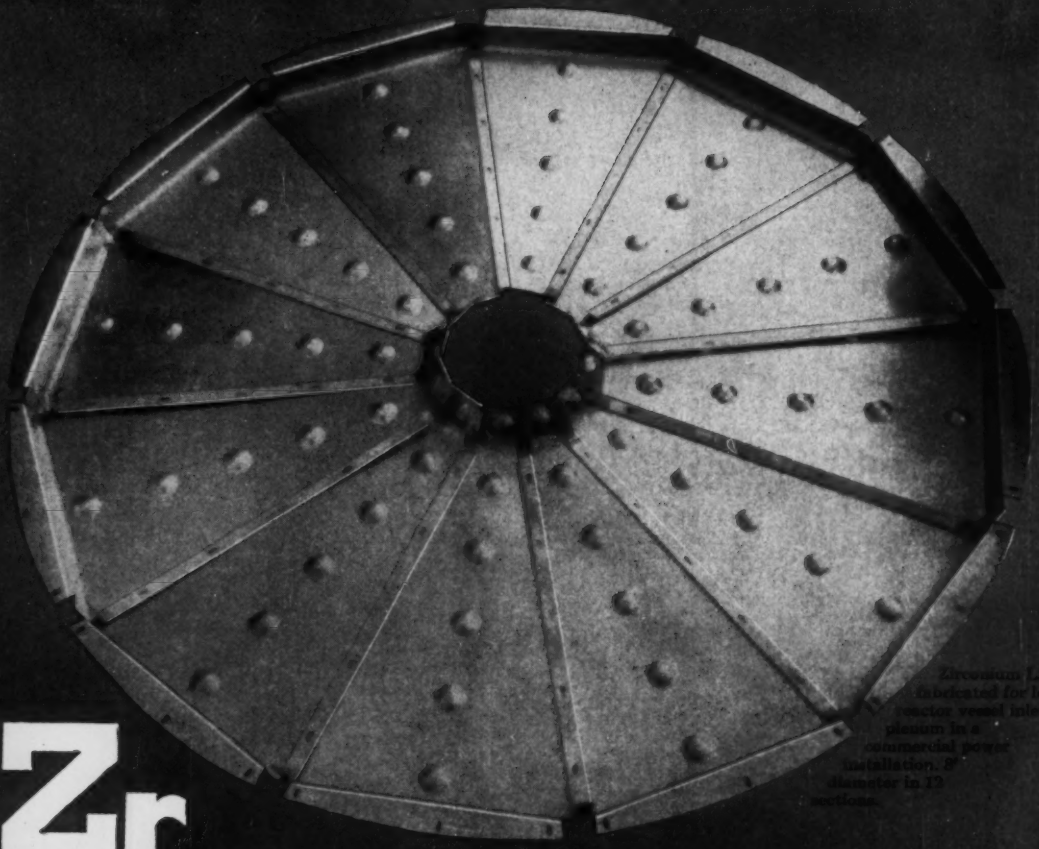

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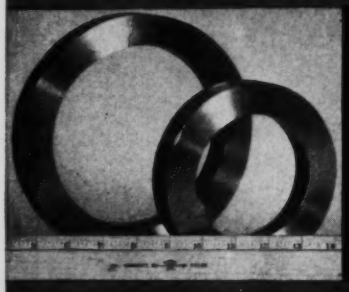

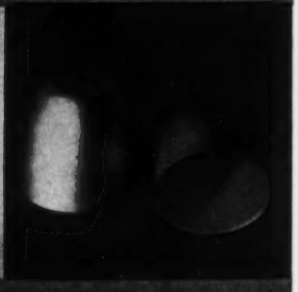

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	3	5.8	—0.10	27000
	5	5.8	+0.20	36000
	7	5.8	+0.30	40000
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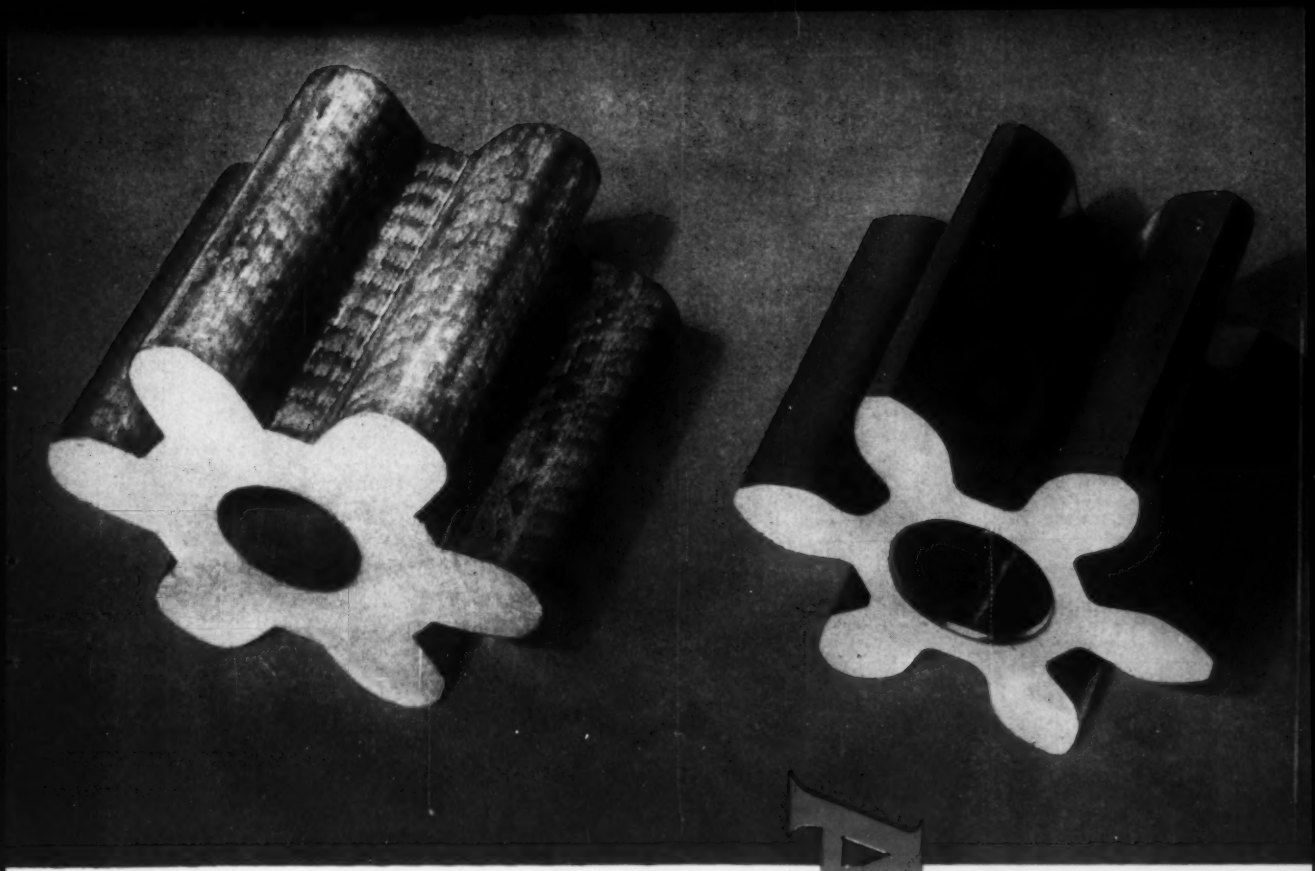

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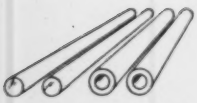
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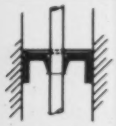
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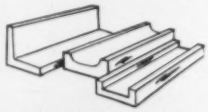
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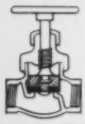
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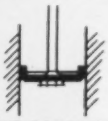
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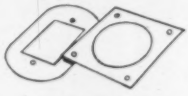
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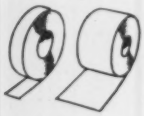
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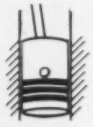
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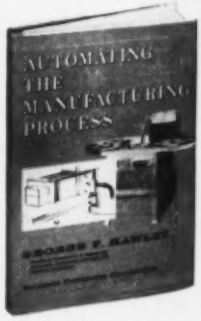

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by RAYMOND E. WIECH, JR. and ROBERT F. STRAUSS,
Supervisors, Research Group
Thiokol Chemical Corporation
Reaction Motors Division

1960, illustrated, 145 pages, $5.50

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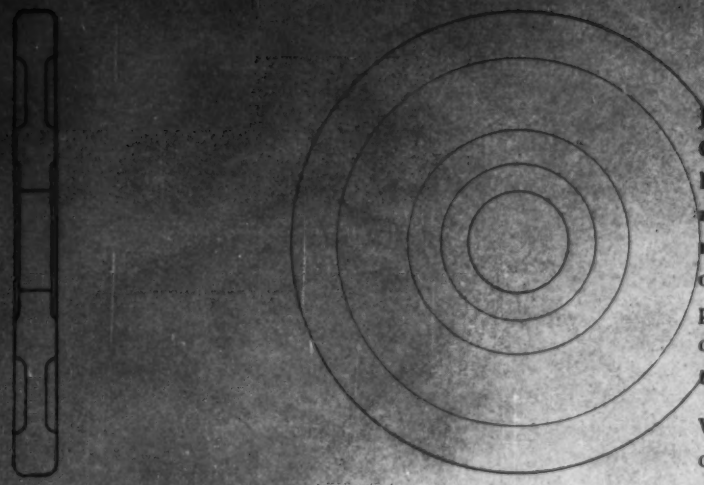

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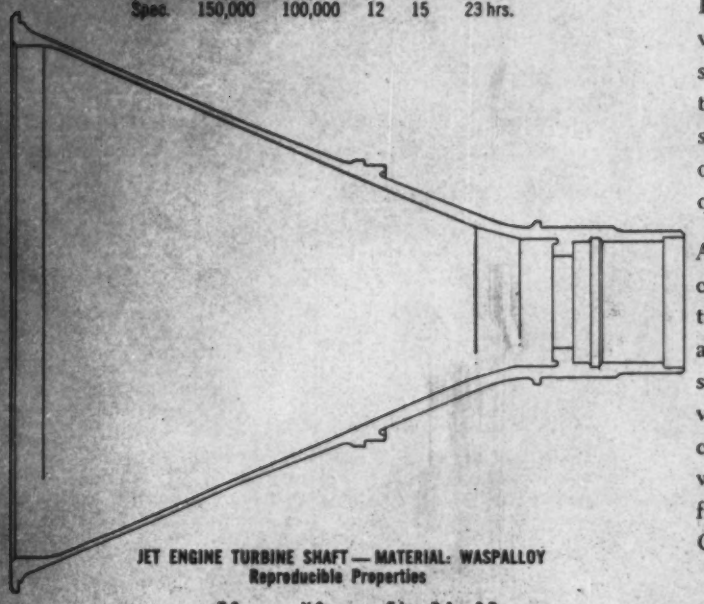

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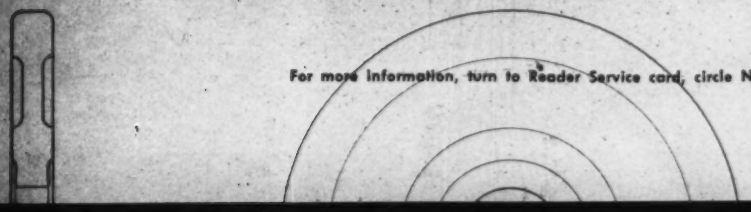

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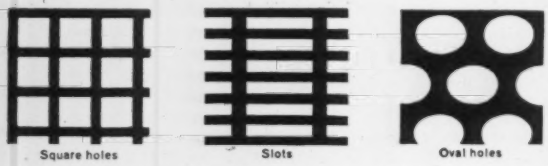

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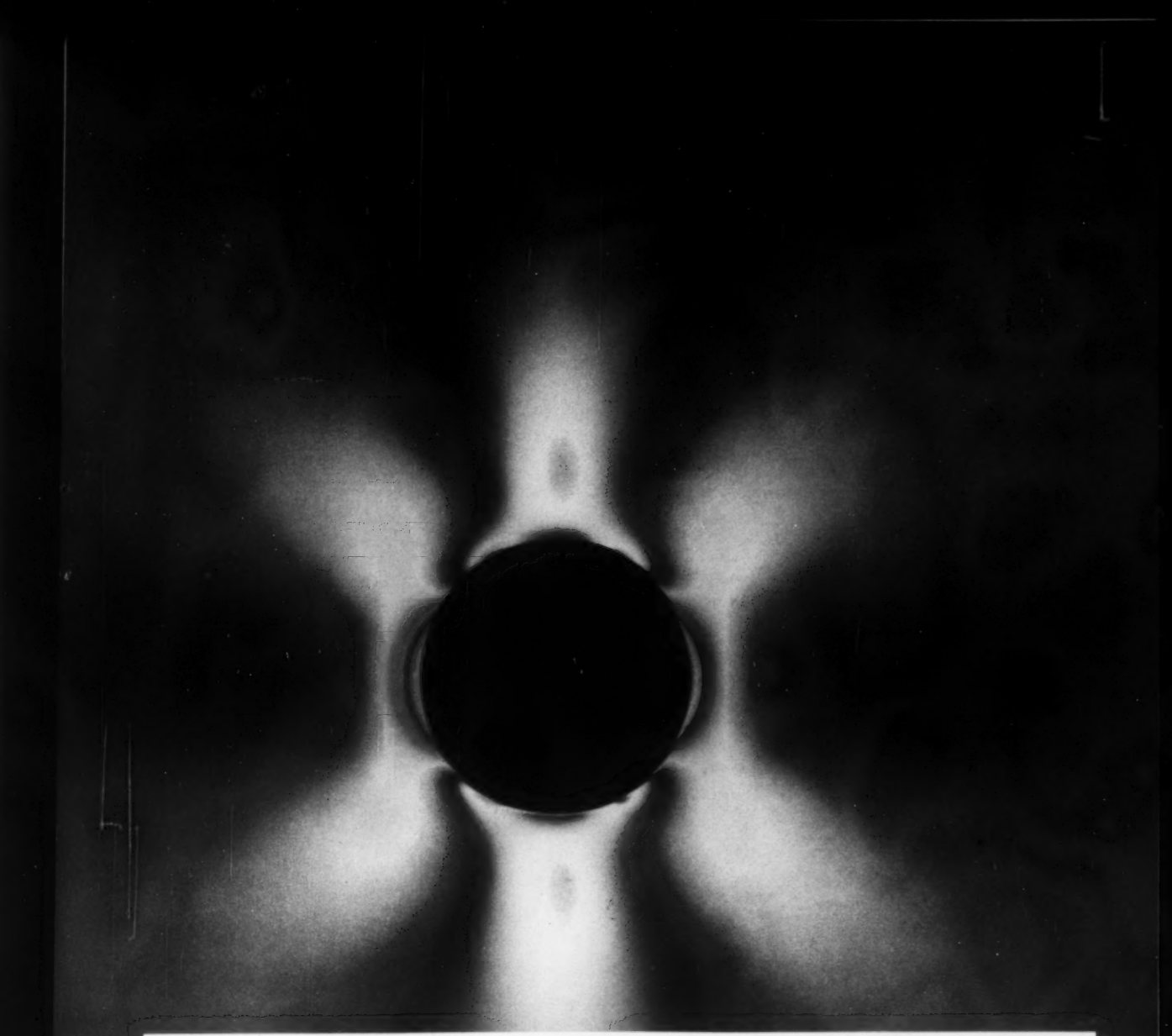

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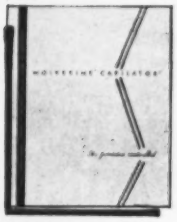

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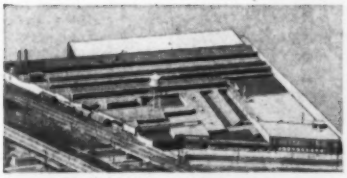

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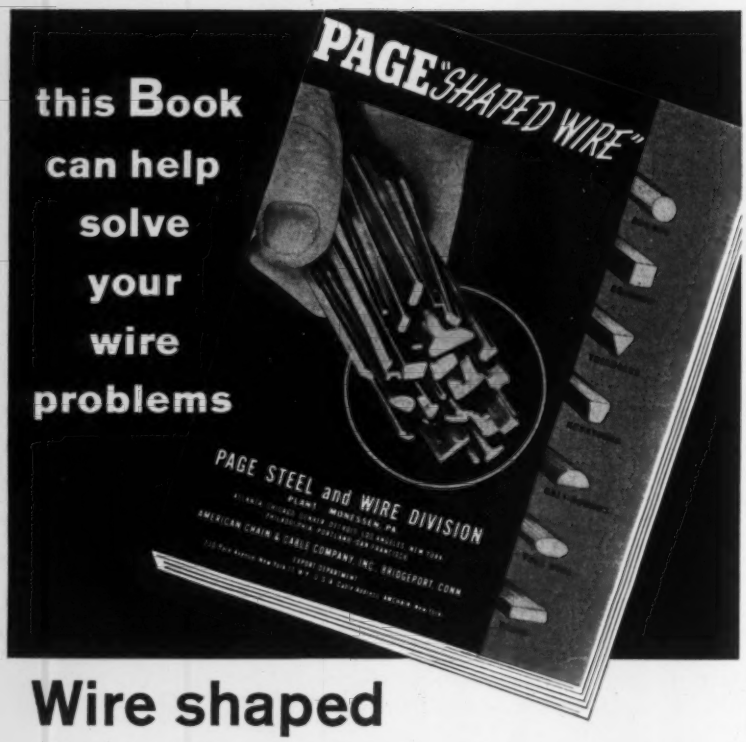

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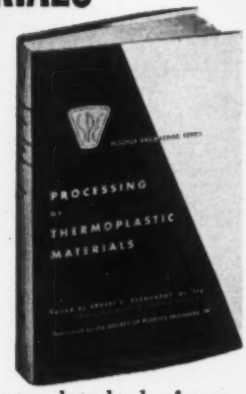

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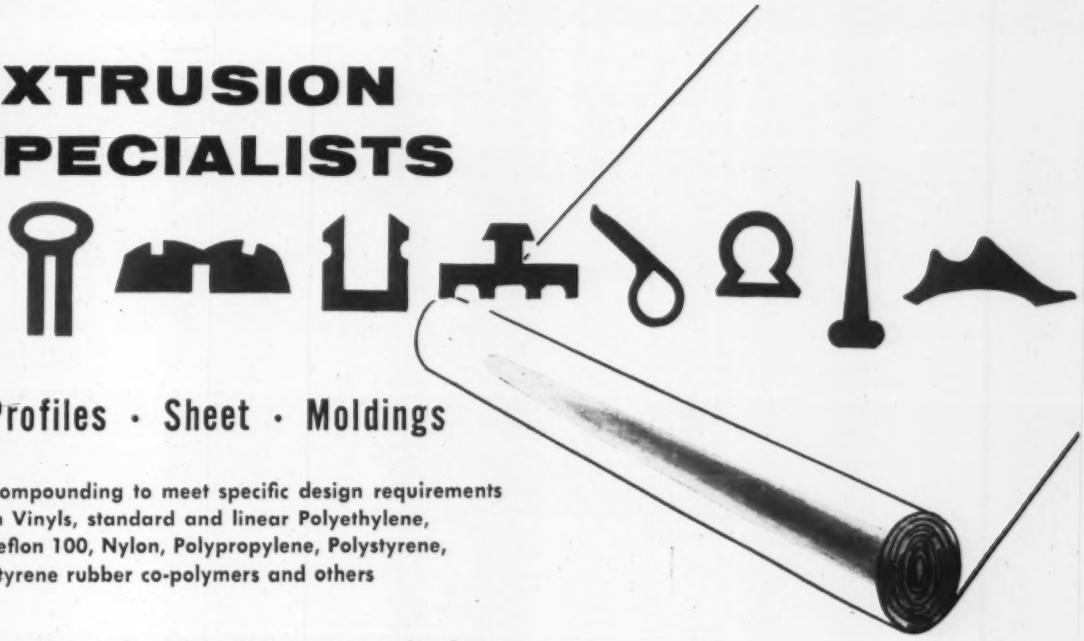

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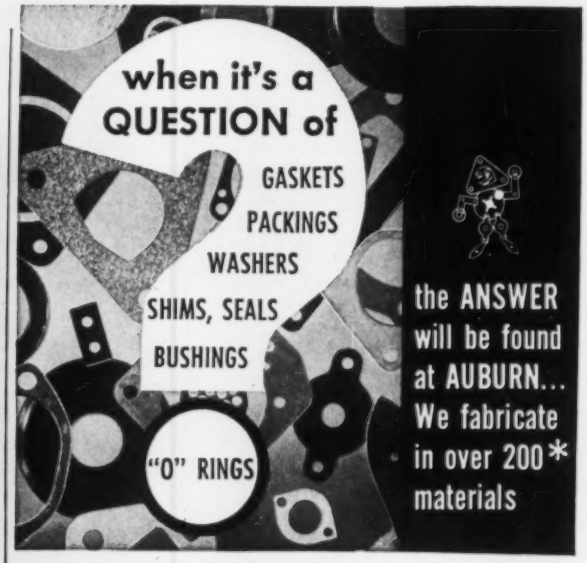

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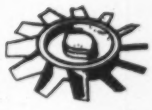

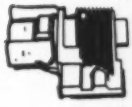

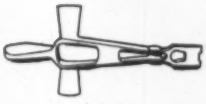

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RANGE OF MECHANICAL PROPERTIES

	ZINC ALLOYS	ALUMINUM ALLOYS	MAGNESIUM ALLOYS
Impact Strength	43-48, CHARPY (toughest)	2-8, CHARPY	1-2, IZOD
Tensile Strength	41,000-48,000 (strongest)	30,000-45,000	30,000-33,000
Shearing Strength	31,000-38,000 (toughest)	19,000-28,000	20,000
Elongation	7-10 (most ductile)	2-9	1-3
Brinell Hardness	82-91 (hardest)	50-80	60-62
CASTING CHARACTERISTICS			
Ease, Speed of Casting	(easiest)		
Maximum Feasible Size	(greatest)		
Complexity of Shape	(most complex)		
Dimensional Accuracy	(most accurate)		
Minimum Section Thickness	(thinnest)		
Surface Smoothness	(smoothest)		
COST			
Die Cost*	(lowest)		
Production Cost	(lowest)		
Machining Cost	(next to lowest)		
Finishing Cost**	(lowest)		
Cost per piece***	(lowest)		
EXTENT OF USE			
Extent of Use	(most used)		

*Dies for casting the low melting point alloys are least expensive and have longest life.

**Includes polishing and buffing expense as well as ease of applying all types of commercial finishes, both electrodeposited and organic.

***Based on die and fuel costs, production speed and machining and finishing costs.

NOMINAL RANGE	HORSE HEAD BRASSES	HORSE HEAD NICKEL SILVERS
Copper	70-90%	64%
Nickel	—	18%
Lead	0-1.75%	0-1.5%
Zinc	remainder	remainder
PROPERTIES AND CONSTANTS		
Tensile Strength	23,000-41,000	23,000-31,000
Elongation	8-34	7-15
Rockwell H Hardness	58-81	78-80
Electrical Conductivity	154,000-205,000	32,000

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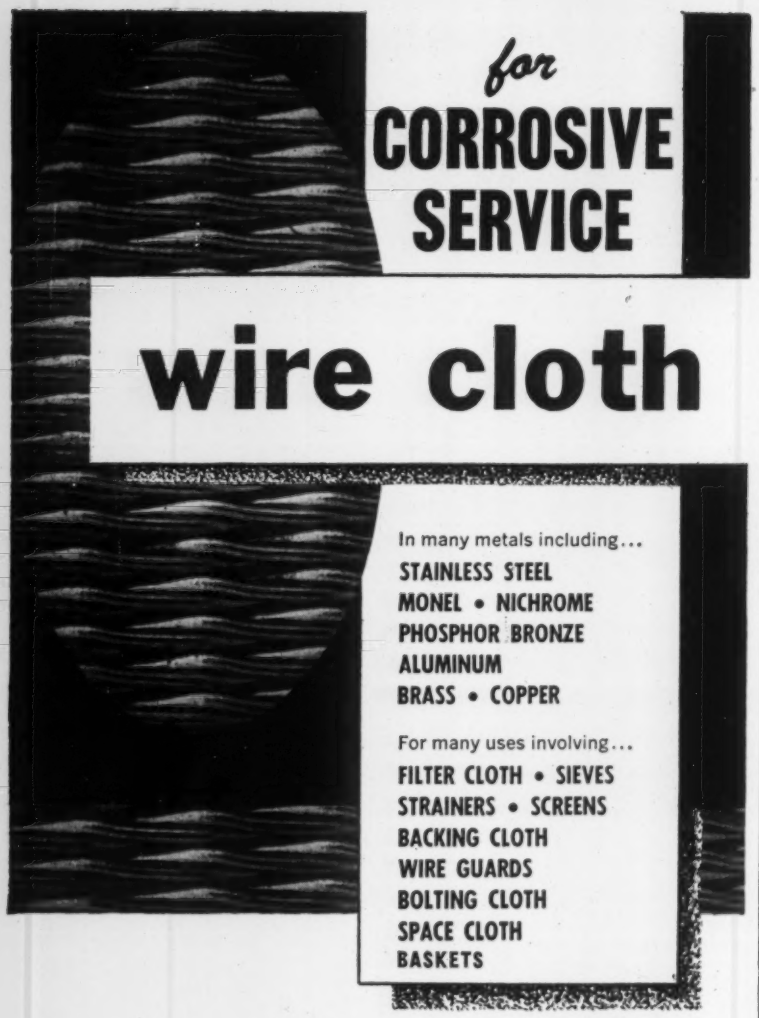

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This useful materials information service can also bring you any of the literature listed on page 364. Review the advertisements and the literature listings, then make use of this free service. A moment of your time is all it takes. The literature you will receive has been prepared especially to help you solve materials application problems.

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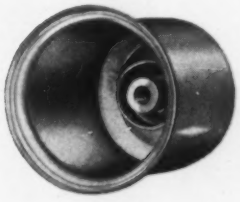

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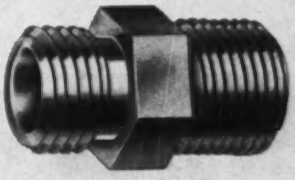

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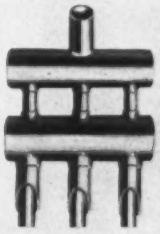
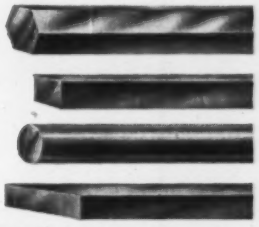
SAND CASTINGS



FORMED COPPER TUBE



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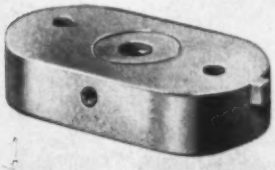

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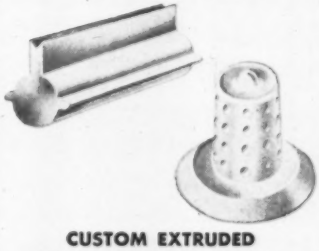

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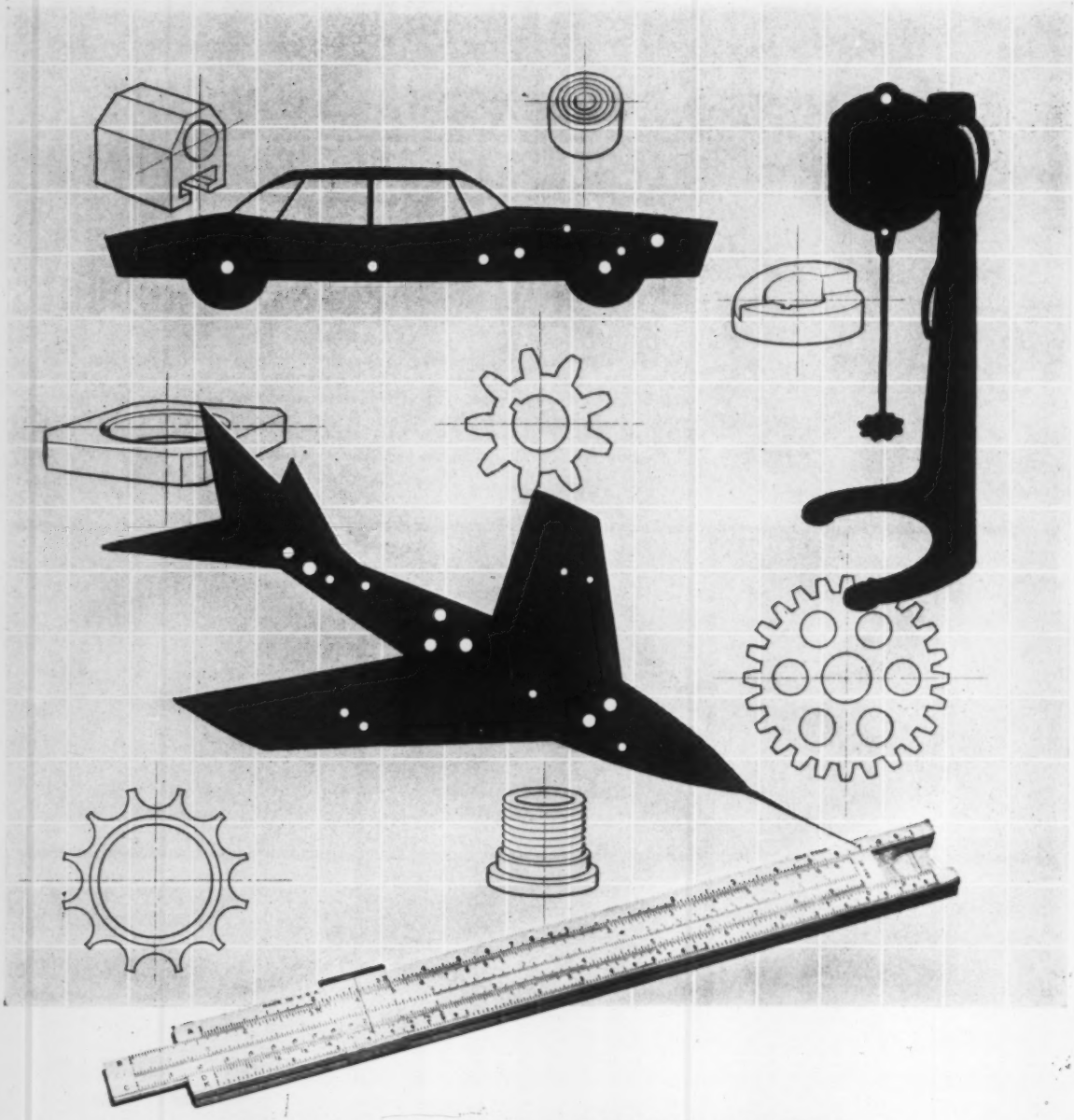

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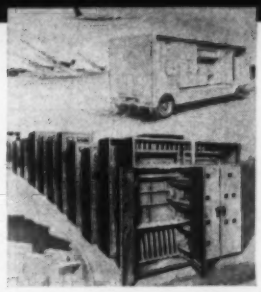

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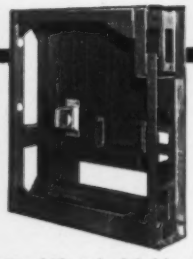
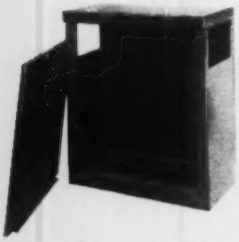


Welded Aluminum Electronic Chassis Assembly weighs 17 pounds. Overall dimensions, 23¾" x 20⅞" x 7⅜". 28 formed parts, 123 certified spot welds.



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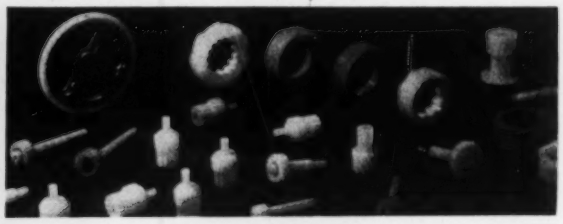

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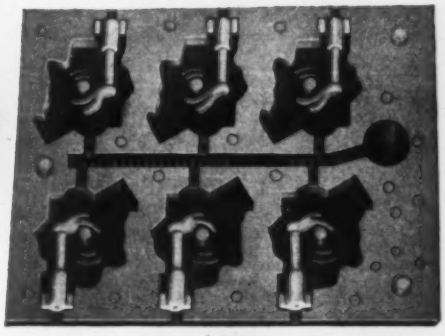
EATON SHELL MOLDING



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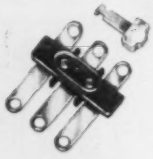
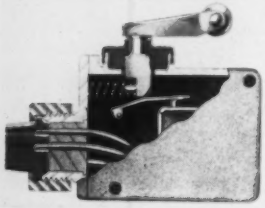


PLASTICS

PRECISION MOLDING

Mass production of precision parts ranging from phase lead insulating caps of silicone rubber (shown at far left designed for room temperature vulcanizing) to switch parts of mineral-filled silicone resin (lower right, designed to retain dimensional stability at temperatures of 2000° F.) calls for precision production techniques gained only through experience.

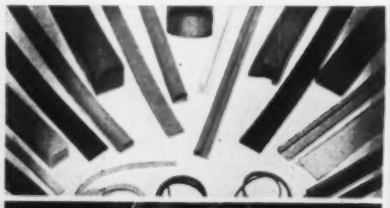


PRECISION BONDING

Environment proof limit switches (like this one for airborne equipment) call for completely sealed construction. These seals (shown in red) are silicone rubber bonded to metal by Moxness . . . evidence of Moxness ability to handle the most exacting requirements in this specialized field.

PRECISION EXTRUDING

Large, small, simple or complex . . . here are samples of the wide range of quality silicone rubber extrusions you can expect from Moxness. Special equipment and an exclusive process developed by Moxness also assures you of paying less for precision extrusions when you order from Moxness.



PRECISION TAPES

The coil shown here is being insulated with NEW Guide Line Triangular MOX-TAPE which provides homogeneous void-free insulation for motors (class H and B) with a single wrap. Mox-Tape fuses to itself . . . eliminates messy pastes or adhesives. Cuts taping time 50 to 60%.

*DU PONT VITON, TEFLON; 3M KEL-F

MOXNESS Subs. Nat'l Rivet and Mfg. Co.

MOXNESS PRODUCTS, INC.

1965 INDIANA STREET • RACINE, WISCONSIN

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For more data on

SHORT RUN PRESS-FORMED PARTS

MECHANICAL TUBING

METAL STAMPINGS

Reprints of **MATERIALS IN DESIGN ENGINEERING MANUALS** on these engineering materials are now available at 35¢ per copy. Each Manual is a complete and comprehensive discussion to guide you in materials selection and use. If you would like copies, write today.

"Short Run Press-Formed Parts," 16 pp. This summary helps you adapt the mass production press to economical forming of relatively small quantities of sheet metal parts. Tells about rubber press pad, flexible female die, flexible male die and drop hammer methods; kind of parts each can form; aids you in designing for short run production. Methods are discussed in light of: Forming Principles; Materials Formed; Advantages and Limitations; Design Considerations.

"Mechanical Tubing" (20 pp.) a versatile, basic metal form manufactured specifically for further processing into fabricated parts. Its advantages of inherent structural strength, weight saving, and reduction of production time and costs make it attractive for the design of a wide variety of products. This manual outlines the available types and shapes of mechanical tubing, the ways in which it can be fabricated, and typical applications. It gives the principal characteristics of these tubing materials: Steel, Stainless, Copper, Nickel, Aluminum, Magnesium, Titanium and Specialty Alloys.

"Designing Metal Stampings," 16 pp. A designer not fully informed on the stamping process can cost his company a lot of money by failing to consider stampings when he should or by designing stampings that result in costly production. This manual tells how to design for the stamping process; covers blank layout, holes, bends, radii, tolerances; and discusses the working characteristics of the metals commonly used.

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PROPERTIES OF MEEHANITE METAL

GENERAL ENGINEERING TYPES

	GM	GA	GB	GC	GD	GE
Tensile Strength — psi	55,000	50,000	45,000	40,000	35,000	30,000
Modulus of Elasticity — psi	22,000,000	20,000,000	18,000,000	17,000,000	14,500,000	12,000,000
Modulus of Rupture — psi	93,000	88,950	84,700	82,000	74,100	61,000
Compression Strength — psi	200,000	175,000	160,000	150,000	130,000	120,000
Fatigue Strength — psi	25,000	22,000	19,000	17,500	15,000	13,700
Shear Strength — psi	over 55,000	48,000	44,000	40,000	35,000	30,000
Impact Strength — Charpy — ft. lbs.	8.0	7.2	5.8	4.5	3.2	2.1
Brinell Hardness (as cast)	>217	>207	>207	>195	>183	>174
Machinability Rating	50	48	48	47	44	38
Specific Gravity	7.34	7.31	7.28	7.25	7.22	7.06

HEAT RESISTING TYPES

	HE	SP HE	HD	HB	HR	SC	HS
Maximum Working Temperature	Thermal Shock	Thermal Shock	1150°F	1400°F	1450°F	1650°F	1700°F
Tensile Strength — psi	30,000	35,000	33,000	38,000	40,000	27,000	60/100,000
Modulus of Elasticity — psi	10,000,000	14,000,000	17,500,000	19,000,000	21,000,000	17,500,000	23,000,000
Transverse Strength — lbs.	2300	2800	2600	2860	2860	1500	4000
Deflection — inches	.28	.28	.24	.26	.24	.17	.40
Brinell Hardness (as cast)	< 207	< 241	223 Approx.	300 or over	300 or over	>228	>196
Thermal Conductivity 50°-450°F BTU/Hr./Sq. Ft./Inch Thickness °F	298	300	325	360	350	278	290
Coefficient of Thermal Expansion Per °F — from 100°F to 1000°F	.00000666	.00000670	.00000709	.00000728	.00000743	.00000674	.00000740

NODULAR "S" TYPES

	SP-80	SH-100	SF-60	HS	WS
Tensile Strength — psi	80/100,000	100/170,000	60/80,000	60/100,000	60/80,000
Yield Strength — psi	60/75,000	70/130,000	45/60,000	45/75,000	50/65,000
Elongation	3%-10%	1%-5%	15%-25%	2%-10%	2%-4%
Brinell Hardness	207/267	263/600	150/190	>196	400/525
Impact (ft. lbs.)	45/60	35/50	60/115	up to 115	up to 180 on 1.2" bar

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Tensile Strength — psi	>50,000	up to 70,000	>50,000	40/50,000	60/80,000	>30,000	>65,000
Brinell Hardness	227/350	250/600	>550	350/600	400/525	575	up to 550

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Tensile Strength — psi	>45,000	40/45,000	>32,000
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Compression Strength — psi	160,000	160,000	130,000
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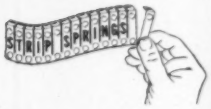

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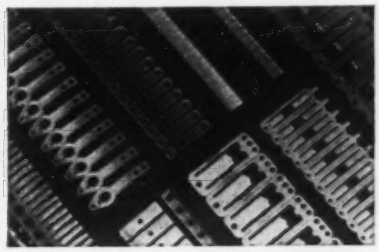

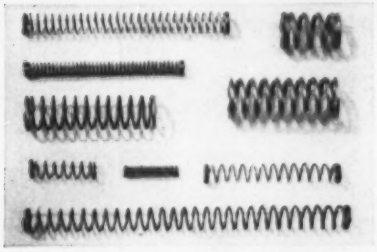

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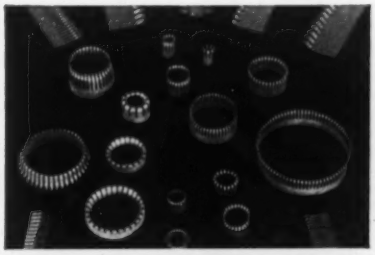

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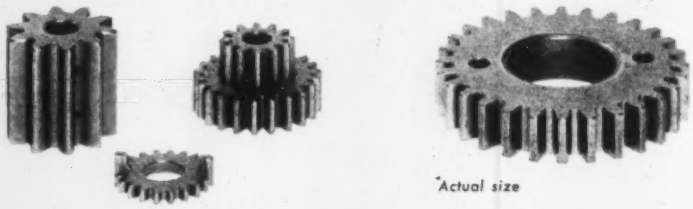

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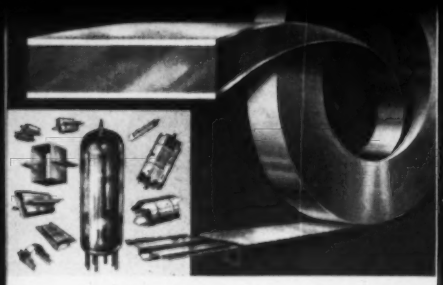

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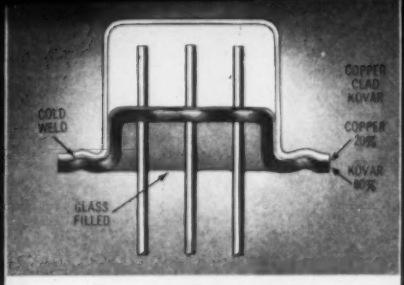

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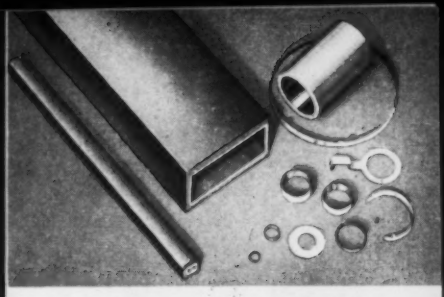

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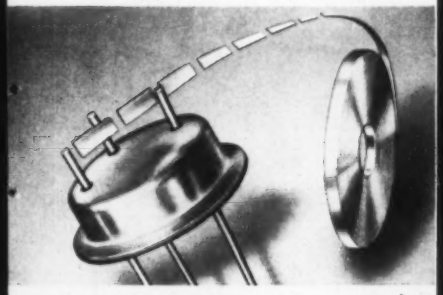

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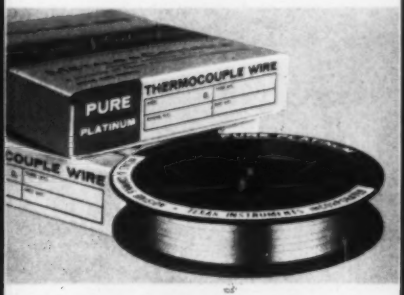

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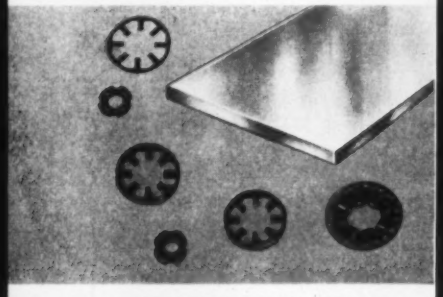

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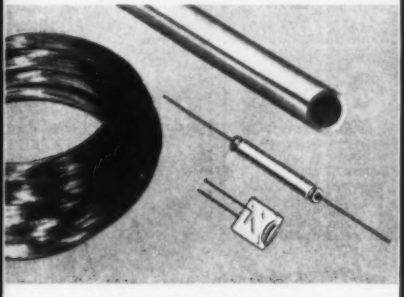

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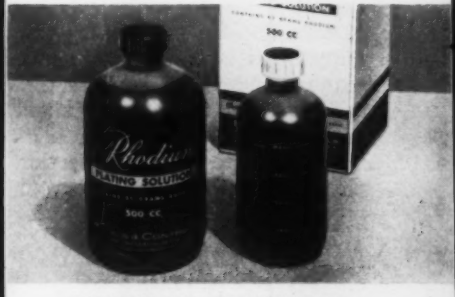

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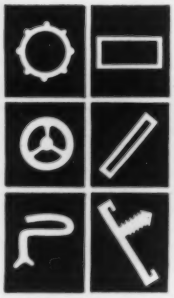

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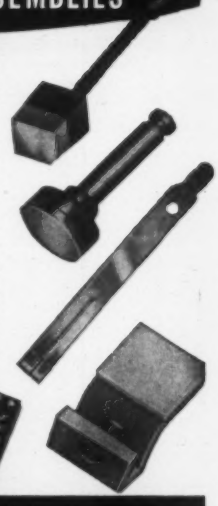

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CA-40	12-1	.20-.40	11.5-14.0%	1% max	—	—	—
CB-30	20-2	.30 max.	18.0-22.0%	2% max	—	—	—
CC-50	28-4	.50 max	26.0-30.0%	4% max	—	—	—
CE-30	28-10	.30 max	26.0-30.0%	8-11%	—	—	—
CF-8	20-10	.08 max	18.0-21.0%	8-11%	—	308	—
CF-20	20-10	.20 max	18.0-21.0%	8-11%	—	—	—
CF-8M	20-10	.08 max	18.0-21.0%	9-12%	2-3% Mo.	316	30316
CF-12M	20-10	.12 max	18.0-21.0%	9-12%	2-3% Mo.	—	—
CF-8C	20-11	.08 max	18.0-21.0%	9-12%	8xC min-1% max Cb (or) 10xC min-1.35% max Cb + Ta	347-348	30347
CF-16F	20-10	.16 max	18.0-21.0%	9-12%	1.50% Mo. max-.20/.35% Se	303 Se	—
CH-20	24-14	.20 max	22.0-26.0%	12-15%	—	309	30309
CK-20	25-21	.20 max	23.0-27.0%	19-22%	—	310	30310

HEAT RESISTANT

CSTG	TYPE	C	Cr	Ni	Other
HA	9-0	.20 max	8.0-10.0%	—	.90-1.20% Mo.
HC	28-4	.50 max	26.0-30.0%	4% max	—
HD	28-5	.50 max	26.0-30.0%	4-7%	—
HE	28-10	.20-.50	26.0-30.0%	8-11%	—
HF	21-10	.20-.40	19.0-23.0%	9-12%	—
HH	26-12	.20-.50	24.0-28.0%	11-14%	.20% N max
HI	28-16	.20-.50	26.0-30.0%	14-18%	—
HK	26-20	.20-.60	24.0-28.0%	18-22%	—
HL	30-20	.20-.60	28.0-32.0%	18-22%	—
HN	21-25	.20-.50	19.0-23.0%	23-27%	—
HT	15-35	.35-.75	13.0-17.0%	33-37%	—
HU	19-39	.35-.75	17.0-21.0%	37-41%	—
HW	12-60	.35-.75	10.0-14.0%	58-62%	—
HX	17-66	.35-.75	15.0-19.0%	64-68%	—

LOW ALLOY

	GRADE OF STEEL →	T-LOY 34 AISI 8635			T-LOY 42 AISI 8640		
CHEMICAL ANALYSIS	CARBON	0.30% – 0.38%			0.38% – 0.46%		
	MANGANESE	0.70% – 0.90%			0.70% – 0.90%		
	SILICON	0.60% MAXIMUM			0.60% MAXIMUM		
	NICKEL	0.60% – 0.90%			0.90% – 1.10%		
	CHROME	0.40% – 0.60%			0.60% – 0.80%		
	MOLYBDENUM	0.17% – 0.25%			0.25% – 0.35%		
	PHOS & SULPHUR	0.04% MAXIMUM			0.04% MAXIMUM		
	HEAT TREATMENT	NORM. DRAWN	OIL QUENCHED 1200° F DRAW	OIL QUENCHED 900° F DRAW	NORM. DRAWN	OIL QUENCHED 1200° F DRAW	OIL QUENCHED 900° F DRAW
PHYSICAL PROPERTIES	TENSILE STRENGTH P.S.I.	90,000	105,000	150,000	100,000	120,000	175,000
	YIELD POINT P.S.I.	60,000	85,000	125,000	75,000	100,000	145,000
	ELONGATION IN 2"	22%	17.0%	10.0%	12%	12%	10%
	REDUCTION OF AREA	40%	35.0%	25.0%	25%	28%	25%
	BRINELL HARDNESS	187 MIN.	217-248	302-340	200-250	240 MIN.	350 MIN.

PHYSICAL PROPERTIES BASED ON .505" TEST BAR TURNED FROM A STANDARD 1¼" CAST TEST COUPON

CARBON

	GRADE OF STEEL →	LOW CARBON AISI-1020	MEDIUM CARBON AISI-1025	MED. HIGH CARBON AISI-1035	HIGH CARBON AISI-1045
CHEMICAL ANALYSIS	CARBON	0.27% MAX.	0.20-0.30%*	0.30-0.40%*	0.40-0.50%*
	MANGANESE	0.75% MAX.	0.75% MAX.*	0.75% MAX.*	0.75% MAX.*
	SILICON	0.60% MAX.	0.60% MAX.	0.60% MAX.	0.60% MAX.*
	PHOSPHORUS	0.05% MAX.	0.05%	0.05% MAX.	0.05% MAX.
	SULPHUR	0.05% MAX.	0.05%	0.05% MAX.	0.05% MAX.
PHYSICAL PROPERTIES	TENSILE STRENGTH	60,000 PSI	70,000 PSI	75,000 PSI	85,000 PSI
	YIELD POINT	30,000 PSI	38,000 PSI	43,000 PSI	53,000 PSI
	ELONGATION IN 2"	24%	24% MIN.	18%	18%
	REDUCTION OF AREA	36%	36%	30%	30%
	BRINELL HARDNESS	100-140	140-170	160-190	180-220
IMPORTANT NOTES	LOW CARBON—Note: For each .01% Carbon below maximum, an increase of .04% Manganese will be allowed up to 1.00% Manganese. Residual alloys shall be controlled so as not to exceed at any time the following: Copper—.50%, Nickel—.50%, Chromium and Molybdenum—.25%, Tungsten—.10%. Total of all unspecified alloys not to exceed 1.00%.				
	MEDIUM CARBON—Note: For each .01% Carbon below maximum, an increase of .04% Manganese will be allowed up to 1.00% Manganese.				
	MED. HIGH CARBON—Note: For each .01% Carbon below maximum, an increase of .025% Manganese will be allowed over the maximum.				
	HIGH CARBON—Note: For each .01% Carbon below maximum, an increase of .025% Manganese will be allowed up to 1.00% Manganese.				

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Joinability of Materials[a]

Material ↓	Arc Welding	Oxyacetylene Welding	Resistance Welding	Brazing
Cast Iron	Common by shielded metal arc where ductile weld not required	Rec with cast iron rods; braze welding if no corr or thermal stress	Seldom; if used, flash welding preferred	Dfclt; easiest for quality-controlled and Ni-cont types
Carbon and Low Alloy Steels	Rec for low carbon and low alloy, common for medium, dfclt for high; all processes	Rec with rods of same comp for low carbon, low alloy; incr C makes more dfclt	Rec for low carbon and low alloy; flash and upset used as C incr dfclt	Rec for low, medium carbon; dfclt for high; seldom for heat treated alloy steels
Stainless Steel	Rec for 200 and 300 series, common for 400 series; all processes[b]	Common for thin gages, dfclt for thicker	Rec for 300 series; 400 series susceptible to hardening	Rec with silver brazing alloys[b]
Aluminum, Magnesium	Common by inert gas; Al slightly easier than Mg	Common for Al <1 in., Mg & M1 alloy; others dfclt	Common; Mg more dfclt, though spot welding used	Common for Al alloys and Mg alloy M1
Copper and its Alloys	Common by inert gas; electrolytic Cu joints not high str	Common for most; seldom for phosphor and aluminum bronzes	Common by upset or modified flash upset methods	Rec for Cu and high Cu brasses; ease with bronzes varies widely
Nickel and its Alloys	Rec for Ni, monel, Inconel; all processes	Common for Ni, monel, Inconel	Rec for most; Inconel X dfclt	Rec
Titanium	Common by inert gas	No	Common by spot and flash welding	Difficult
Lead, Zinc	Common for lead by inert gas; no for zinc	Common	Dfclt for zinc, but spot and seam used; no for lead	No
Thermoplastics	(Heated tool welding.) Rec for acrylic sheet, common for most TP sheet	(Hot gas welding.) Rec for polyethylene, PVC; common for other TP's	(Induction welding.) Common for polyethylene, acrylic; metal insert remains integral	No
Thermosets	No	No	No	No
Elastomers	No	No	No	No
Ceramics	No	Seldom	No	No
Glass	Seldom	(Blow torch.) Common	No	No
Wood	No	No	No	No
Leather	No	No	No	No
Fabric	No	No	No	No
Dissimilar Metals	Dfclt; used where melting points are within about 50 °F; galvanic action danger	Dfclt; used when melting points are within about 50° F; galvanic action danger	Dfclt; special procedures because of different thermal prop.; galvanic action danger	Ranges from dfclt to common depending on deg of dissimilarity
Metals to Nonmetallics	No	No	No	No
Dissimilar Nonmetallics	(Hot gas welding.) Dfclt; used on TP's of same basic type	(Hot gas welding.) Dfclt; used on TP's of same basic type	No	No
Dissimilar Thicknesses	Common	Common	Common	Rec

[a] Abbreviations used in the table: TP = Thermoplastic. TS = Thermosetting. Elast = Elastomeric. Rec = Recommended; easily accomplished with excellent results. Common = Commonly and widely used, though some care may be necessary. Dfclt = Difficult; special precautions, equipment, etc., necessary. Seldom = Can be done with more or less difficulty, but not common for one reason or another. No = Not used; impossible or highly specialized case if ever used.

[b] The 300 series requires post weld heat treatment if subjected to corrosive environments.

	Soldering	Adhesive Bonding (TS, TP, Elast)	Adhesive Bonding (modified compounds)	Threaded Fastening	Riveting and Metal Stitching
	Seldom; graphite and high silicon content prevent bonding	Common with TS, seldom with TP	Common with epoxy 100% solids; dfclt with solvent-dispersed phenolic	Common; esp self-tapping, also integrally cast studs, hooks, etc.	Rec with large solid rivets in structural uses
	Dfclt for lower carbon; seldom for higher carbon	Common with TS, seldom with TP	Common with epoxy 100% solids in paste form	Rec with all types; most fasteners made of same mtls	Rec with solid rivets for high shear, medium ten str uses
	Common for 300 series with high tin solders; dfclt for 400 series	Common with TS, seldom with TP	Common with epoxy 100% solids in paste form	Rec with bolts and nuts, common with others	Common with solid stainless steel rivets for high shear str uses
	Seldom; special solders available	Rec with TS, common with others, but no alkaline adh	Rec with all types	Common with self-tapping screws, inserts, others	Common with small solid aluminum rivets, or semi-tubular where low stress
	Rec for copper, brass, bronze in that order	Common with TS, seldom with TP, but no natural rubber adh	Common with epoxy 100% solids as paste or film	Common with fasteners available in similar mtls	Common with small solid copper alloy rivets, seldom with semi-tubular
	Common with high tin solders or others rel noncorr	Common with TS, seldom with TP	Common with epoxy 100% solids as paste or film	Rec with fasteners available in similar mtls	Common with small solid nickel alloy rivets, seldom with semi-tubular
	Seldom	Seldom with TS, no TP	Common with epoxy 100% solids, heat and pressure-cured	Common; some Ti fasteners available	No
	Rec with low melting solders	Rec with TS, TP, Elast in that order	Rec with all types	Rec with self-tapping screws, inserts, special fasteners	Rec with semi-tubular or split rivets, seldom with solid
	No	Common with Elast for cryst types; solvent selection care nec to avoid crazing	Seldom; phenolic-Buna N most used	Seldom; inserts are used, also special fasteners	Rec with tubular rivets; stitching common (limited thk)
	No	Common with TS; solvent selection care nec to avoid crazing	Common with modified epoxies on TP–TS compounds	Common with self-tapping screws, elevator bolts, inserts	Rec with semi-tubular rivets
	No	Rec with phenolic, epoxy and neoprene adhesives	Common with epoxy-polysulfide, phenolic-elastomers	Seldom; inserts are used, also special fasteners	Rec with tubular or split rivets; stitching common
	No	Rec with epoxy, common with other TS adhesives exc ureas	Rec with vinyl-phenolics, modified epoxies, phenolic-elastomers	Common with nuts, washers and bolts, esp load-indicating types	Seldom; semi-tubular rivets used
	No	Rec with TS, common with Elast	Rec with vinyl-phenolics, phenolic-elastomers	Common with plastics fasteners, seldom with elevator bolts	Seldom; TP semi-tubular rivets used
	No	Rec; phenolic for soft plywood, melamine-urea for laminations, PVC for furniture	Rec with solvent-dispersed phenolic-elastomers, latex emulsions	Rec with wood and lag screws, self-tapping screws, inserts, dowels, etc.	Common. Semi-tubular rivets for hard woods, tubular rivets for soft
	No	Rec with Elast, common with TS	Rec with asphalt and latex emulsions, solvent dispersions	Seldom	Rec with tubular and split rivets, and stitching or stapling
	No	Rec with Elast, polyvinyl acetate and cellulosic adh	Rec with asphalt and latex emulsions	Seldom	Rec with split rivets, stitching
	Rec except where galvanic corr must be considered	Rec with TS exc solvent-dispersed types	Rec with epoxy 100% solids	Common but galvanic action may be a danger	Common although galvanic action is a danger
	No	Rec. TP for shear str; TS Elast for peel str	Rec with solvent-dispersed phenolic-elastomers	Common using self-tapping screws, inserts, special fasteners	Rec with self-tapping screws, inserts, stitching
	No	Rec; type varies with porosities being joined	Rec; type varies with porosities being joined	Seldom	Rec with lag screws, stitching, special fasteners
	Rec	Rec where load is not peel	Rec with all types	Rec, esp bolts	Rec, esp stitching

Brazing and Soldering Alloys

Classification

Unlike welding filler metals, these alloys melt at lower temperature than the metals being joined —brazing alloys above 800 F, soldering alloys below.

Brazing Alloys. Alloys are classified by chemical composition. The two most common groups are silver alloys and copper and copper alloys. All must melt and flow freely at a lower temperature than the metals being joined, adhere to the surfaces being joined, and not oxidize or volatize too freely.

Brazing fluxes. Choice of the proper brazing flux is extremely important. Fluxes minimize oxidation, dissolve oxides that may have formed, and promote free flowing of the filler metal. A great number of proprietary fluxes are available, each with specific recommendations for use. Most of them can be classified as high temperature (above 1500 F), general-purpose low-temperature, or special purpose.

Soldering alloys. The most widely used soft solders are those composed of tin and lead, with or without other minor alloying elements. Other types include lead-silver, silver-tin-lead, bismuth-tin-lead, indium-bearing and aluminum solders.

Soldering fluxes. The most important factor in producing a sound soldered joint is the proper choice and use of a flux. The many available fluxes can be classified in two groups—corrosive and noncorrosive.

Brazing and Soldering Methods

Similar methods of heating are used for brazing and soldering. However, the furnace and salt dip methods are seldom used for soldering, and the soldering iron is not used for brazing. The most common methods use:

Soldering iron. The "iron" has a copper tip which is generally heated electrically. It is used mostly for electrical connections.

Torch. Oxyacetylene, oxyhydrogen or other gas flame torches are widely used for repair work.

Induction heating. Parts are assembled in a fixture which positions them inside an induction coil. Advantageous for large quantities of small parts.

Electric block. Similar to resistance welding with lower current. Used for small electrical parts.

Salt dip. Brazing alloy is preloaded into the work and parts are dipped into molten salt bath. Advantageous for dissimilar thicknesses and aluminum.

Metal dip. Parts are dipped in bath of molten brazing or soldering alloy. Used for irregular shapes.

Furnace. Brazing alloy is preloaded into work (usually held in jigs) which is then heated to brazing temperature in a controlled atmosphere furnace. Economical for large volumes of work.

Design Factors

Comparisons. Though brazed joints are not as strong as welded, the lower temperatures required are advantageous in that the process is faster, is performed more economically, and results in less distortion. Soldered joints are not recommended where any stress will be applied.

Joint design. Three basic types of joints are used in brazing: butt, scarf and lap. Lap joints are preferred where maximum strength is preferred. Butt joints are not recommended for soldering.

SOLDERING FLUXES

Flux ↓	Characteristics	Uses
Rosin	Noncorrosive, nonconducting, nonhygroscopic	Electrical
Tallow	Very mildly corrosive	Lead, brass, clean copper
Olive Oil or Gallipoli Oil	Very mildly corrosive	Pewter, block tin
Stearic Acid	Mildly corrosive, almost nonconductive	Electrical, lead
Aniline Phosphate or Aniline Chloride	Mildly corrosive, almost nonconductive	Electrical
Lerulinic Acid in Alcohol	Mildly corrosive, almost nonconductive	Tin cans
Lactic Acid, Phthalic Acid and Phosphoric Acid Mixed with Tallow, Resin, etc.	Mildly corrosive, slightly conductive	Electrical
Zinc Chloride	Corrosive	Iron, steel, zinc, copper, brass, bronze; terne and lead plate
Zinc Chloride and Hydrochloric Acid	Corrosive	Stainless steel, nickel, monel
Zinc Chloride and Hydrofluoric Acid	Corrosive	Brasses and bronzes containing aluminum, silicon and manganese
Orthophosphoric Acid	Corrosive	High tensile manganese bronze
Numerous Proprietary Pastes Usually Containing Zinc Chloride	Corrosive	—
Zinc Chloride and Ammonium Chloride	Corrosive	Iron, zinc, copper, brass, bronze
Dilute Hydrochloric Acid	Corrosive	Dirty zinc
Fused Salts of Zinc Chloride and Ammonium Chloride	Corrosive	Dipping method

Definitions

Eutectic. An alloy which has a melting *point* and not a *range*.

Liquidus. The lowest temperature at which the alloy is completely liquid.

Melting range. The range from the liquidus to the solidus temperature.

Solidus. The temperature at which the alloy begins to melt.

TYPICAL SOFT SOLDERS

ASTM Type ↓	Nominal Composition	Solidus, F	Liquidus, F	Spec Grav	Ten Str, 1000 psi	Applications
TIN-LEAD ALLOYS						
70A, 70B	Sn 70, Pb 30, Sb 0.12–0.50	361	378	8.32	6.8	Soldering Zn-coated ferrous metals; coating metals
.....	Sn 62, Pb 38	361	361	—	—	General purpose; eutectic alloy
60A, 60B	Sn 60, Pb 40, Sb 0.12–0.50	361	374	8.65	6.4	General purpose, esp where temp needs critical
50A, 50B	Sn 50, Pb 50, Sb 0.12–0.50	361	421	8.85	5.9	General purpose; most commonly used for iron, steel, Cu alloys, Zn. Domestic plumbing
45A, 45B	Sn 45, Pb 55, Sb 0.12–0.50	361	441	8.97	—	Auto radiator cores, roofing seams
40A, 40B	Sn 40, Pb 60, Sb 0.12–0.50	361	460	9.3	5.8	Wiping lead pipes, cable sheaths. Auto radiator cores, galvanized iron and Zn heating units
35A, 35B	Sn 35, Pb 65, Sb 0.25–0.50	361	477	9.5	—	General purpose; wiping solder
30A, 30B	Sn 30, Pb 70, Sb 0.25–0.50	361	491	9.7	5 6	Machine, torch, dip, wiping methods
25A, 25B	Sn 25, Pb 75, Sb 0.25–0.50	361	511	10.00	—	Machine, torch methods
20B	Sn 20, Pb 80, Sb 0.5	361	531	10.20	5.3	Joining metal parts $<\frac{1}{4}$ in. thk; filling dents or seams in auto bodies; coating metals
15B	Sn 15, Pb 85, Sb 0.50	361	550	10.50	—	Joining, coating; tinning auto bodies
10B	Sn 10, Pb 90, Sb 0.50	361	570	10.80	—	Joining, coating
5A, 5B	Sn 5, Pb 95, Sb 0.12–0.50	518	594	11.30	3.4	Joining and coating, esp at high temp to 250 F
TIN-LEAD-ANTIMONY ALLOYS*						
.....	Sn 94, Pb 0.2, Sb 4–6	450	464	—	—	General purpose
40C	Sn 40, Pb 58, Sb 1.8–2.4	365	448	9.23	—	Same as 50A, 50B
35C	Sn 35, Pb 63.2, Sb 1.6–2.0	365	470	9.44	—	General purpose; wiping
30C	Sn 30, Pb 68.4, Sb 1.4–1.8	364	482	9.65	—	Torch, machine methods
25C	Sn 25, Pb 73.7, Sb 1.1–1.5	364	504	9.96	—	Same as above
20C	Sn 20, Pb 79, Sb 0.8–1.2	363	517	10.17	—	Machine soldering and coating; tipping
TIN-LEAD-INDIUM ALLOYS						
.....	Sn 37.5, Pb 37.5, In 25.0	274	358	—	—	Where res to strong alk soln needed (high cost)
SILVER-LEAD AND SILVER-CADMIUM ALLOYS						
2.5 S	Sn 0, Pb 97.5, Sb 0.40, Ag 2.3–2.7	579	579	11.35	5.0	Cu, brass and similar metals with torch heating. Suitable for high temp but not for humid environ.
1.55	Sn 1, Pb 97.5, Sb 0.40, Ag 1.3–1.7	588	588	11.28	—	Cu, brass and similar metals with torch heating. Sealing tin cans. High temp use
.....	Ag 5, Cd 95	640	750	—	—	High temp use
CADMIUM-ZINC AND LEAD-CADMIUM-ZINC ALLOYS						
.....	Pb 90, Cd 8, Zn 2	410	530	—	—	Zn and galvanized parts
.....	Cd 82.5, Zn 17.5	508	508	—	—	Zn-base die castings; high temp
LOW MELTING ALLOYS (BISMUTH-CONTAINING)						
.....	Bi 56, Pb 22, Sn 22	203	220	—	—	Special uses where low mp needed in soldering or svc
.....	Bi 67, Pb 16, Sn 17	203	300	—	—	Same as above
.....	Bi 40, Sn 60	281	338	—	—	Same as above
.....	Bi 42.5, Pb 32.7, Sn 11.3, Cd 8.5	158	194	—	—	Same as above
.....	Bi 58, Sn 42, Zn 4	266	266	—	—	Same as above
ALLOYS FOR SOLDERING ALUMINUM						
.....	Sn 55–70, Zn 30–45	630	—	—	—	Range of special alloys for Al; also used on Mg
.....	Sn 75, Zn 25	401	500	—	—	Soldering capacitors to Al sheets
ALLOYS FOR SOLDERING MAGNESIUM						
.....	Sn 60, Zn 40	630	—	—	—	Magnesium
.....	Cd 60, Zn 30, Sn 10	315	—	—	—	General purpose
.....	Cd 90, Zn 10	500	—	—	—	Magnesium

* Not recommended for use on galvanized iron, cadmium or zinc parts.

continued on next page

Brazing and Soldering Alloys

BRAZING FILLER METALS

AWS-ASTM Class ↓	Major Composition %	Available Forms	Solidus, F	Liquidus, F	Special Factors
ALUMINUM-SILICON					
BAlSi-1	Si 4.0–6.0, Al bal	Strip, wire, rod	1070	1165	—
BAlSi-2	Si 6.8–8.2, Al bal	Coated sheet	1070	1135	Only as coating on 3003, 5951
BAlSi-3	Si 9.3–10.7, Cu 3.3–4.7, Al bal	Strip, wire, rod	970	1085	—
BAlSi-4	Si 11.0–13.0, Al bal	Strip, wire, powder	1070	1080	Highly corr res
COPPER-PHOSPHORUS					
BCuP-1	P 4.75–5.25, Cu bal	Strip, wire	1305	1650	More ductile than others; less fluid
BCuP-2	P 6.75–7.50, Cu bal	Rod	1305	1485	Very fluid
BCuP-3	P 6.00–6.50, Ag 4.75–5.25, Cu bal	Wire, rod, powder	1195	1500	Very fluid
BCuP-4	P 6.75–7.80, Ag 5.75–6.25, Cu bal	Rod, powder	1185	1380	—
BCuP-5	P 4.75–5.25, Ag 14.50–15.50, Cu bal	Strip, wire, rod, powder	1185	1500	Suitable where close fits cannot be held
SILVER					
BAg-1	Ag 44–46, Cu 14–16, Zn 14–18, Cd 23–25	↑	1125	1145	Free flowing, narrow melting range
BAg-2	Ag 34–36, Cu 25–27, Zn 19–23, Cd 17–19		1125	1295	Free flowing, broader melting range than above
BAg-3	Ag 49–51, Cu 14.5–16.5, Zn 13.5–17.5, Cd 15–17, Ni 2.5–3.5		1195	1270	Good wetting action on carbide; wide melting range; good corr res
BAg-4	Ag 39–41, Cu 29–31, Zn 26–30, Ni 1.5–2.5		1240	1435	Same as above, but freer flowing
BAg-5	Ag 44–46, Cu 29–31, Zn 23–27		1250	1370	Wets, flows well; malleable, ductile
		Strip, wire, rod, powder			
BAg-6	Ag 49–51, Cu 33–35, Zn 14–18		1270	1425	Same as above; low elec res, high ductility
BAg-7	Ag 55–57, Cu 21–23, Zn 15–19, Sn 4.5–5.5		1145	1205	Less stress corr cracking on stainless, some Ni alloys
BAg-8	Ag 71–73, Cu 27–29		1435	1435	Free flowing except on ferrous metals
BAg-9	Ag 64–66, Cu 19–21, Zn 13–17		1280	1325	—
BAg-10	Ag 69–71, Cu 19–21, Zn 8–12		1335	1390	—
BAg-11	Ag 74–76, Cu 21–23, Zn 2.5–3.5	↓	1365	1450	—
COPPER-GOLD					
BCuAu-1	Au 37.25–37.75, Cu bal	Strip, wire	1775	1815	[f]
BCuAu-2	Au 79.75–80.25, Cu bal	Strip, wire	1620	1630	[f]
COPPER					
BCu	Cu 99.90 min	Strip, wire, rod	1980	1980	Free flowing
COPPER-ZINC					
BCuZn-1	Cu 58.0–62.0, Zn bal	Strip, wire, rod	1650	1660	Free flowing; mod str
BCuZn-2	Cu 57.0 min, Sn 1.0, Zn bal	Strip, wire, rod	1630	1650	Free flowing; higher str than above
BCuZn-3	Cu 56.0 min, Sn 1.10, Mn 1.0, Ni 1.0, Zn bal	Strip, wire, rod	1590	1630	Used for capillary brazing
BCuZn-4	Cu 50.0–55.0, Zn bal	Grain	1570	1595	Low mp; somewhat brittle
BCuZn-5	Cu 50.0–53.0, Sn 3.0–4.5, Zn bal	Grain	1585	1610	Used for capillary brazing
BCuZn-6	Cu 46.0–50.0, Ni 9.0–11.0, Zn bal	Strip, wire, rod	1690	1715	Generally used to make V fillet
BCuZn-7	Cu 46.0–48.0, Ni 10.0–11.0, Ag 0.30–1.0, Zn bal	Strip, wire, rod, powder	1685	1710	High mp; good color match
MAGNESIUM					
BMg	Al 8.3–9.7, Zn 1.7–2.3, Mg bal	Wire, rod	770	1110	Good corr res; high str, ductility
HEAT RESISTING MATERIALS					
BNiCr	Ni 65–75, Cr 13–20, B 2.75–4.75[k]	Strip, wire, powder	1850	1950	Retains prop. to 2000 F
BAgMn	Ag 84–86, Mn 14–16	Strip, wire, rod	1760	1780	Good str at 500–900 F

[a] Immersion in 10% sulfuric acid restores copper color.
[b] BCuP-1: particularly resistance, and some furnace brazing.
[c] Lap and tee; strong, ductile joint; shear strength 20–30,000 psi.
[d] BAg-7 particularly for furnace brazing.
[e] All ferrous and nonferrous metals except Al, Mg, Ti and other metals melting below 1500 F. BAg-9, 10, 11 are used together for step brazing.

Brazing Methods	Brazing Temp Range, F	Flux	Nature of Joint	Color of Braze	Uses
Furnace, dip	1150–1185	↑	Lap. Clearance <0.010 in.	Gray	Wrought Al alloys: 1100, 3003,
Furnace	1120–1140		for laps <¼ in. long;	Gray	3004, 5050, 6951, 6053, 6061,
Furnace, dip	1060–1185	Essential	but >0.025 in. for longer	Gray	6062, 6063. Cast Al alloys:
Torch, dip, furnace	1090–1185	↓	laps	Gray	A612, C612
↑	1450–1700	↑	Clearance: 0.002–0.005 in.[a]	Lt Gray[a]	Cu, Cu alloys; limited use for Ag,
	1350–1550		Clearance: 0.001–0.003 in.[a]	Lt Gray	W, Mo. Do not use on ferrous
All methods[b]	1300–1550	Self-fluxing on	Clearance: 0.002–0.005 in.[a]	Lt Gray	alloys containing more than 10%
	1300–1500	copper; flux rec on	Clearance: 0.001–0.003 in.[a]	Lt Gray	Ni. Not rec for sulfurous atm
↓	1300–1500	other metals ↓	Clearance: 0.003–0.005 in.[a]	Lt Gray	above room temp
↑	1145–1400	↑	↑	Lt Yellow	Unstabilized types of stainless[a]
	1295–1550			Lt yellow	Where tolerances cannot be as closely controlled[a]
	1270–1500			Whitish yellow	Joining carbide tool tips to tool shanks[a]
	1435–1650		Lap rec; butt sometimes	Lt yellow	Carbide tip brazing[a]
	1370–1550	Required unless	used. Clearances 0.002–	Lt yellow	Elec equip.; food and dairy equip.
		brazing is done in	0.005 in. Fatigue str about		where Cd-containing alloys
All methods[d]		vacuum or inert	that of metals being joined		might be prohibited[a]
	1425–1600	atm	(to 27,000 psi). Tough,	Lt yellow	Same as above
	1205–1400		ductile, high impact str;	Whitish	Food and dairy equip.[a]
			ten str, 50–60,000 psi		
	1435–1650			White	Assembling electronic tubes[a]
	1325–1550			Whitish	Particularly with sterling silver[a,f]
	1390–1600			Whitish	Same as above
↓	1450–1650	↓	↓	Whitish	Same as above
Induction, furnace, resistance	1815–2000	None[e]	—	Copperish	Special alloy for joining parts in electron tube assemblies
Same as above	1630–1850	None[e]	—	Copperish	Same as above
Furnace[h]	2000–2100	None[i]	Clearance: 0.000–0.002 in.[j]	Yellow	Ferrous metals; Ni and Cu-N alloys
Torch, furnace, induction	1670–1750	↑	↑	Yellow	Steels, Ni and Cu alloys
"	1670–1750			Yellow	Same as above
"	1670–1750			Yellow	Same as above
		Required; borax-	Lap, butt; clearances 0.002–		
"	1600–1700	boric acid com-	0.005 in. High str in shear	Pale yellow	Steels, Ni alloys
"	1620–1700	monly used	and tension	Grayish yellow	Same as above
All methods	1720–1800			Gray	Same as above
All methods	1690–1800	↓	↓	Gray	Same as above
Torch, furnace, dip; sometimes others except resistance	1120–1160	Req; fluxes contain KCl, NaCl, some fluorides	Lap; clearances 0.004–0.010 in.	Gray	Mg alloy M1A
Furnace, generally using controlled dry H_2 atm	2000–2150	None in red. atm; otherwise necessary	Variable	Gray	Stainless steels, high Ni alloys; jet engines
Same as above	1780–2100	Same as above	Variable	Gray	Stainless steels, high Ni alloys; lower temp than BNiCr

[a] Variation in brazing temp permits step brazing.
[b] Using H_2 or dissociated ammonia atmosphere.
[d] Otherwise same nature as CuZn alloys.
[e] In reducing atmosphere or vacuum; otherwise borax-boric acid flux.
[f] Except on metals with oxide constituents.
[h] Total Fe + Si + C = 10% max.

Joining & Fastening

Welding Electrodes and Rods

Classification

Welding rods and electrodes are generally grouped broadly according to the major metal (or metals) of which they are composed. Some are also grouped by the metals which they are used to weld. (These two classifications are often identical because it is usually desirable to weld base metals with a filler metal of similar composition.) A few groups of rods and electrodes are also defined by the welding method with which they are used.

Each broad group of rods and electrodes is further classified according to one or more of the following factors: chemical composition; coating, current and welding position; mechanical properties; appearance of the weld; intended end use. The key chart below is designed to indicate the method of classifying

EXPLANATION OF AWS-ASTM ROD AND ELECTRODE CLASSIFICATION NUMBERS
(And Key to the Charts in This Welding Section)

Electrode or Rod Group ↓	AWS-ASTM Spec	Sample Class No.[a]	Type of Specified Conditions Indicated by Class No.[b]	See Table No. . .
WELDING IRONS AND STEELS				
Mild Steel (coated and covered)	A233-58T	E6010	60—properties; 10—manner of use[e]	2a, 2b
Low Alloy Steel (covered)	A316-58T	E7010[e]	70—properties; 10—manner of use	2a, 2b
		E7010-A1[e]	70—properties; 10—modifies comp; A1—comp of weld	2a, 2c
Stainless Steel (covered)	A251-46T	E308ELC-15	308—comp of weld; ELC—modifies comp; 15—manner of use. Properties are also specified[d]	3
Stainless Steel (bare)[f]	A371-53T	ER308L	308—comp as mfd; L—modifies comp	3
For Welding Cast Iron[g]	A398-56T	RCuAl-A2	CuAl—comp as mfd; A2—modifies comp. Visual examination of weld is also specified[d]	4
For Gas Welding Irons and Steels	A251-46T	GA65	A65—properties	5
WELDING NONFERROUS METALS				
Copper and Copper Alloy	B225-53T (electrodes)	ECuAl-A2	CuAl—comp as mfd; A2—modifies comp. Properties are also specified[d]	6
	B259-52T (rods)	RCuAl-A2	CuAl—comp as mfd; A2—modifies comp	6
Nickel and Nickel Alloy	B295-54T (covered electrodes)	E3N10[h]	3—base metal; 1—welding method; 0—comp of core as mfd. Comp of weld, tensile strength are also specified[d]	7
	B304-56T (bare electrodes and rods)	ERN60	6—welding method; 0—comp as mfd	8
Aluminum and Aluminum Alloy	B184-43T (covered electrodes)	Al-2	2—comp of core as mfd	9
	B285-54T (bare electrodes and rods)	R-CN42A[i]	CN42—comp as mfd	9
Magnesium and Magnesium Alloy[f]	No specifications; alloys can be joined by gas welding and inert-gas shielded arc processes. In general, filler metal should have same composition as alloy being joined			
Lead and Zinc	No specifications; gas welding most commonly used. In general, filler metal should have same composition as alloy being joined			

[a] The first letter of the designation is either "E" for electrode or "R" for rod.
[b] The figures used are samples, e.g., the "10" for mild steels may be 11, 12, etc., each indicating a different manner of use. Properties = Mechanical properties of the deposited weld metal. (The figures approximate the minimum tensile strength in units of 1000 psi.) Manner of use = Type of current, polarity (if d.c.), welding position, type of covering.
[c] These figures also indicate modifications of specified properties and whether or not weld composition is specified.
[d] Specified, but not represented in the classification number.
[e] Must be classified one way or the other, not both.
[f] Used as both rods and bare electrodes. As rods—atomic hydrogen and inert-gas metal arc (nonconsumable electrode) welding. As bare electrodes—submerged arc and inert-gas metal-arc (consumable electrode) welding.
[g] Includes rods for oxyacetylene and carbon arc welding, covered electrodes for shielded metal arc welding. Types included here are: cast iron, copper-base, nickel-base and mild steel.
[h] The "N" designates "nickel."
[i] The "A" designates "aluminum."

1—TYPICAL PROPERTIES OF MILD STEEL ARC WELDED DEPOSITS

AWS—ASTM Class ↓	Ten Str, 1000 psi	Yld Point, 1000 psi	Elong (in 2 in.), %	Red. of Area, %	Impact Str, ft-lb[a]	Endur Limit, 1000 psi	Brinell Hardness
E4510, E4520	45	—	5	—	—	—	—
E6010	60–68	48–58	22–28	35–60	30–40, 15–25	28–32	140–160
E6011	60–70	48–61	22–30	35–60	30–40, 15–25	28–32	140–160
E6012	60–78	48–65	17–22	20–40	20–30, 5–15	—	150–170
E6013	60–78	48–65	17–22	25–50	25–35, 5–20	—	150–170
E6020, E6030	60–68	48–58	25–30	40–60	25–35, 15–25	30–34	150–170
E6027	60–68	48–55	25–30	40–60	25–35, 15–25	30–34	150–170
E6014	60–72	48–60	17–25	30–50	25–35, 15–25	—	—
E7014	70–85	58–77	17–25	30–50	25–35, 15–25	—	—
E6015, 6016	60–72	48–60	22–35	55–75	35–50, 25–40	—	140–160
E7015, 7016	70–76	58–62	22–35	55–75	35–50, 25–40	—	—
E6018	60–72	48–60	22–30	55–75	35–50, 25–40	—	—
E7018	70–85	58–70	22–30	55–75	35–50, 25–40	—	—
E6024	60–72	48–60	17–22	20–40	25–35, 10–20	—	150–170
E7024	70–85	58–75	17–22	20–40	25–35, 10–20	—	150–170
E6028	60–72	48–60	22–30	55–75	35–50, 25–40	—	—
E7028	70–85	58–74	22–30	55–75	35–50, 25–40	—	—

[a] Charpy keyhole. First value is at 70 F, second at −40 F.

each group according to American Welding Society specifications.

In some cases there is a choice offered by the specification; the manufacturer may be allowed to select one of several classification methods, or may be allowed to list an electrode by more than one classification.

The numbered charts on this and the following six pages classify the rods and electrodes within each group by the applicable method and also give other information, such as method of use, typical properties and some common applications.

Welding Processes

Arc welding. A group of processes wherein coalescence is produced by heating with an electric arc. The metal to be welded is one pole of an electric circuit and the electrode is the other pole. A suitable gap forms a heat generating arc. (The metal participates in the production of heat but is not the sole source.) Carbon or metal electrodes may be used. If covered metal electrodes are used the process is referred to as *shielded*. There are other methods of shielding, such as using an inert gas (helium or argon), or a blanket of granular, fusible material on the work (referred to as *submerged arc welding*).

Braze welding. Uses a brazing torch but is classified technically as a welding process because the filler metal is distributed by gravity and not, as in brazing, by capillary action.

Gas welding. A group of processes wherein coalescence is produced by heating with a gas flame, most commonly obtained by the combustion of acetylene with oxygen (*oxyacetylene welding*).

Resistance welding. A group of processes wherein coalescence is produced by the heat generated from resistance to flow of electric current through the work, and by pressure. Heat is generated in two places: in the body of the work where only the resistivity of the material determines the amount of heat; and at contact surfaces where resistivity is affected by pressure, surface oxides and compounds, and surface roughness and cleanliness. No fluxes or filler metals are used. Various types of resistance welding processes are named according to the method of determining pressure points. Examples

Definitions

Filler metal. A broad term for the metal added in making a weld. It may or may not carry electric current.

Rod. Filler metal, in wire or rod form, which does not carry current. Rods are used in gas welding or in arc welding with a separate carbon or tungsten electrode.

Electrode. The current-carrying element. With three exceptions, it is also the filler metal. Carbon and tungsten electrodes are not filler metals. The third exception is the "resistance welding electrode," a term applied to the part of the resistance welding machine that transmits current (and usually pressure) to the work. A resistance welding electrode may be in the form of a wheel, bar, cylinder, clamp, etc.

Bare, lightly coated, covered. Terms which apply to filler metals (either rods or electrodes) used in arc welding. However, since rods are usually bare, the terms are generally reserved for filler metal electrodes. The purpose of a light coating is primarily to stabilize the arc. "Covered" wires have a relatively thick coating which protects the molten metal from the atmosphere, improves weld metal properties, and stabilizes the arc.

Welding Electrodes and Rods

2a—MILD AND LOW ALLOY STEEL COVERED ELECTRODES
(Classified by Current, Welding Position and Covering)

AWS-ASTM Class ↓	Current, Polarity	Welding Position[a]	Covering	Slag[b]	Deposition Rate	Arc Characteristics
Exx10[c]	D.c. reversed	F, V, OH, H	High cellulose sodium	Thin	Slow	Spray, deep penetration
E6011	A.c. or d.c. reversed	F, V, OH, H	High cellulose potassium	Thin	Slow	Spray, deep penetration
E6012	A.c. or d.c.	F, V, OH, H	High titania sodium	Dense	Medium	Globule, medium penetration
Exx13	A.c. or d.c. straight	F, V, OH, H	High titania potassium	Medium	Med fast	Globule, shallow penetration
Exx14	A.c. or d.c.	F, V, OH, H	Iron powder, titania	Medium	Med fast	Globule, medium penetration
Exx15	D.c. reversed	F, V, OH, H	Low hydrogen sodium	Heavy	Medium	Globule, medium penetration
Exx16	A.c. or d.c. reversed	F, V, OH, H	Low hydrogen potassium	Heavy	Medium	Globule, medium penetration
Exx18	A.c. or d.c. reversed	F, V, OH, H	Iron powder, low hydrogen	Heavy	Fast	Globule, shallow penetration
Exx20[c]	A.c. or d.c.	H fillets, F	High iron oxide	Heavy	Fast	Spray, medium penetration
E6024	A.c. or d.c. either polarity	H fillets, F	Iron powder, titania	Heavy	Fast	Spray, shallow penetration
E6027	A.c. or d.c.	H fillets, F	Iron powder, iron oxide	Heavy	Fast	Spray, medium penetration
Exx28	A.c. or d.c. reversed	H fillets, F	Iron powder, low hydrogen	Dense	Fast	Spray, deep penetration
E6030	A.c. or d.c. either polarity	F	High iron oxide	Dense	Fast	Spray, deep penetration

[a] F = flat, V = vertical, OH = overhead, H = horizontal. [b] All slag deposits are readily removable except E6012 which is rated "fair."
[c] When xx = 45, the only column in this table that applies is "Welding Position." Current and polarity of 4510 and 4520 are not specified, but generally d.c. straight polarity is used. These two electrodes are not covered but are either sulcoated or light coated.

2b—MILD AND LOW ALLOY STEEL COVERED ELECTRODES
(Classified by Minimum Mechanical Properties)[a,b]

AWS-ASTM Class ↓	Ten Str, 1000 psi	Yld Point, 1000 psi	Elong (in 2 in.), %
MILD ALLOY STEEL ELECTRODES			
4510, 4520	45	Not spec	5
6010, 6011	62	50	22
6012, 6013, 6014, 6024	67	55	17
6015, 6016, 6018, 6028	67	55	22
6020, 6027, 6030	62	50	25
LOW ALLOY STEEL ELECTRODES			
70xx	70	57	22[c]
80xx	80	67	19[d]
90xx	90	77	17[e]
100xx	100	87	16[f]
110xx	110	97	15
120xx	120	107	14

[a] Classification by mechanical properties is represented by the first two digits. For low alloy steel electrodes the digits are exactly the minimum tensile strength in units of 1000 psi. For mild alloy steel the digits are approximately the minimum tensile strength.
[b] Chemical composition of low alloy steel welds is an alternative classification (see 2c). Chemical composition of mild alloy steel welds is additionally specified for electrodes of the following classes: Exx14-15-16-18-24-28. For these classes the maximum percentage composition is: Mo 0.30, Cr 0.20, Mn 1.25, Ni 0.30, V 0.08 (in addition the sum total of these elements shall not exceed 1.50%) and Si 0.90.
[c] Elongation is 25% for 7020. [e] Elongation is 14% for 9013.
[d] Elongation is 16% for 8013. [f] Elongation is 13% for 10013.

2c—LOW ALLOY STEEL COVERED ELECTRODES
(Classified by Chemical Composition of Weld)[a]

↓ AWS-ASTM Class	Composition (max), %
CARBON-MOLYBDENUM STEEL	
A1	C 0.12, Mo 0.40–0.65
CHROMIUM-MOLYBDENUM STEEL	
B1	C 0.12, Cr 0.40–0.65, Mo 0.40–0.65
B2L	C 0.05, Cr 1.00–1.50, Mo 0.40–0.65
B2	C 0.12, Cr 1.00–1.50, Mo 0.40–0.65
B3L	C 0.05, Cr 2.00–2.50, Mo 0.90–1.20
B3	C 0.12, Cr 2.00–2.50, Mo 0.90–1.20
B4L	C 0.05, Cr 1.75–2.25, Mo 0.40–0.65
NICKEL STEEL	
C1	C 0.12, Ni 2.00–2.75
C2	C 0.12, Ni 3.00–3.75
C3	C 0.12, Ni 0.80–1.10
MANGANESE-MOLYBDENUM STEEL	
D1	C 0.12, Mo 0.25–0.45, Mn 1.25–1.75
D2	C 0.15, Mo 0.25–0.45, Mn 1.65–2.00
OTHER (min %)[b]	
G	Mo 0.20, Cr 0.30, Mn 1.00, Si 0.80, Ni 0.50, V 0.10

[a] Classification of low alloy steel electrodes by chemical composition can be found in AWS-ASTM specification A316-58T. Compositions are represented by a code following the standard classification, modified by the second two digits. This table gives only the percentages of the major elements.
[b] Deposit need have minimum of only one of elements listed.

are: *spot welding* (two welding tips pressing the work together in one spot at a time); and *projection welding* (welding dies are used and pressure points determined by projections designed as an integral part of the work). Other processes are named according to the speed of effecting contact and pressure and their timing with reference to the heating cycle (*flash* and *upset*).

3—STAINLESS STEEL RODS AND ELECTRODES

Covered Electrodes		Rods and Bare Electrodes		Applications	Min Mechanical Properties of Covered Electrode Deposits	
AWS-ASTM Class[a] ↓	Major Composition of Weld Metal, %[b]	AWS-ASTM Class[c] ↓	Major Composition As Manufactured, %[b]		Ten Str, 1000 psi	Elong (in 2 in.), %
E308.....	C 0.08, Cr 18.0–21.0, Ni 9.0–11.0	ER308....	C 0.08, Cr 19.5–22.0, Ni 9.0–11.0	Weld base metal of similar composition	80	35
E308ELC ..	C 0.04, Cr 18.0–21.0, Ni 9.0–11.0	ER308L...	C 0.03, Cr 19.5–22.0, Ni 9.0–11.0	Low C reduces carbide precipitation, avoiding intergranular corrosion without need for stabilizers	75	35
E309.....	C 0.15, Cr 22.0–25.0, Ni 12.0–14.0	ER309....	C 0.12, Cr 23.0–25.0, Ni 12.0–14.0	Weld similar alloys, wrought or cast. Weld 18–8 for severe corrosion conditions	80	35
309Cb.....	C 0.12, Cr 22.0–25.0, Ni 12.0–14.0, Cb+Ta 0.70–1.00	.....	.....	Primarily weld type 347 clad steel or dissimilar metals. Cb stabilizes against intergranular corrosion, provides high strength at high temperatures	80	30
E309Mo...	C 0.12, Cr 22.0–25.0, Ni 12.0–14.0, Mo 2.00–3.00	.....	.....	Primarily weld type 316 clad steels or dissimilar metals (similar to E309 with Mo added, C reduced)	80	35
E310.....	C 0.20, Cr 25.0–28.0, Ni 20.0–22.0	ER310....	C 0.08–0.15, Cr 25.0,[d] Ni 20.0[d]	High strength, ductility useful in welding such hardenable steels as armor plate. Also weld clad steels	80	30
E310Cb....	C 0.12, Cr 25.0–28.0, Ni 20.0–22.0, Cb+Ta 0.70–1.00	.....	.....	Same uses as E309Cb	80	25
E310Mo...	C 0.12, Cr 25.0–28.0, Ni 20.0–22.0, Mo 2.00–3.00	.....	.....	Same uses as E309Mo	80	30
E312.....	C 0.15, Cr 26.0–31.0, Ni 8.5–10.5	.....	.....	Primarily weld cast alloys of similar composition. A recent use: weld dissimilar metals when one is high in nickel	95	22
E316.....	C 0.08, Cr 17.0–20.0, Ni 11.0–14.0, Mo 2.00–2.50	ER316....	C 0.08, Cr 18.0–20.0, Ni 12.0–14.0, Mo 2.0–2.5	Weld similar alloys containing 2 to 3% Mo. Molybdenum content provides creep resistance at high temperatures	80	30
E316ELC ..	C 0.04, Cr 17.0–20.0, Ni 11.0–14.0, Mo 2.00–2.50	ER316L...	C 0.03, Cr 18.0–20.0, Ni 12.0–14.0, Mo 2.0–2.5	Primarily weld extra low carbon, molybdenum-bearing austenitic alloys	75	30
E317.....	C 0.08, Cr 18.0–21.0, Ni 12.0–14.0, Mo 3.00–4.00	ER317....	C 0.08, Cr 18.5–20.5, Ni 13.0–15.0, Mo 3.25–4.0	Weld similar alloys that must meet severe corrosion requirements involving sulfuric and sulfurous acids, salts	80	30
E318.....	C 0.08, Cr 17.0–20.0, Ni 11.0–14.0, Mo 2.00–2.50, Cb+Ta 1.00[e]	....	.....	Primarily weld metals of similar composition (identical to E316 with Cb added)	80	25
E330.....	C 0.25, Cr 14.0–17.0, Ni 33.0 min	ER330....	C 0.15–0.25, Cr 15.0–17.0, Ni 34.0[d]	Repair defects in alloy castings; weld similar alloys. Nickel content gives heat and scale resistance above 1800 F	75	25
E347.....	C 0.18, Cr 18.0–21.0, Ni 9.0–11.0, Cb+Ta 1.00[f]	ER347....	C 0.08, Cr 18.5–21.0, Ni 8.5–10.5, Cb+Ta 1.00[g]	Usually weld Cr-Ni alloys of similar composition stabilized with Cb or Ti	80	30
E410.....	C 0.12, Cr 11.0–14.0, Ni 0.60	ER410....	C 0.07–0.12, Cr 12.0–14.0, Ni 0.6, Mo 0.6	Weld similar alloys; deposit overlays on carbon steels for corrosion, erosion and abrasion resistance. Air-hardening, it requires preheat and post-heat treatment to obtain ductility	70	20
.....	.....	ER420....	C 0.25–0.40, Cr 12.0–14.0, Ni 0.6	Similar to E410, but better resistance to corrosion, abrasion	—	—
E430.....	C 0.10, Cr 15.0–18.0, Ni 0.60	ER430....	C 0.10, Cr 15.5–17.0, Ni 0.6	Similar to E410. Cr limit gives adequate corrosion resistance, yet retains ductility	70	20
E502.....	C 0.10, Cr 4.0–6.0, Ni 0.40, Mo 0.45–0.65	ER502....	C 0.10, Cr 4.5–6.0, Ni 0.4, Mo 0.45–0.65	Weld similar metals, usually pipe or tubing	60	20

[a] The complete classification numbers are *Exxx-15* or *Exxx-16*. The *–15* suffix indicates a lime covering, *–16* a lime or titania covering. Polarity and welding position requirements are the same as those listed in chart 2 for Exx-15 and Exx-16.
[b] Maximum percentages unless otherwise specified. Carbon analysis required to nearest 0.01%.
[c] For consumable electrode welding, d.c. reversed polarity is preferred.
[d] Minimum. [e] Minimum is 6 x C. [f] Minimum is 8 x C. [g] Minimum is 10 x C.

continued on next page

Welding Electrodes and Rods

4—RODS AND ELECTRODES FOR WELDING CAST IRON

AWS-ASTM Class [a] ↓	Common Name[b]	Welding Method	Remarks	Uses
RCI	Cast iron	Oxyacetylene	Produces machinable deposit of same color, composition and structure as base metal	Fill in or build up new or worn gray iron castings. General fabrication, salvage, repair
ECI	Cast iron	Arc; a.c. or d.c. reversed polarity	Basically RCI with heavy covering. Weld metal flows readily; light slag easily removable	Weld and repair gray iron castings; faster than oxyacetylene for repairing small defects
RCI-A	Alloy cast iron	Oxyacetylene	Similar to RCI but higher melting. Weld metal more fluid; welding more rapid	Gray or alloy cast iron to obtain greater tensile strength and finer grain structure than RCI
RCuZn-A[c]	Naval brass	Oxyacetylene	Better strength, corr res than basic 60 Cu-40% Zn alloy. Deposits 70–90 Bhn	Where color match is not required and weldments are not subject to electrolytic corrosion or high temperature service
RCuZn-B[c]	Manganese bronze	Oxyacetylene	Better strength, hardness, corr res than 60 Cu-40% Zn alloy. Deposits 80–110 Bhn	Same as above
RCuZn-C[c]	Low-fuming bronze	Oxyacetylene	Diminishes zinc oxidation (fuming). Slightly higher mechanical properties than naval brass or manganese bronze; deposits 80–110 Bhn	Same as above
RCuZn-D[c]	Nickel bronze	Oxyacetylene	Color is silver rather than yellow. Low fuming. Deposits 90–110 Bhn	Same as above
ECuAl-A2[d], RCuAl-A2[c]	Aluminum bronze (9–11 Al, 1.5% Fe)	Electrodes—arc welding; a.c. and d.c. reversed polarity. Rods—carbon arc welding	Low m.p. permits rapid welding to minimize distortion. Yld and ten str twice those of ECuSn alloys (below)	Weld the new higher strength cast irons. Overlay corrosion and wear resistant surfaces
ECuSn-A[d]	Phosphor bronze (4.8–5.8% Sn)	Arc; d.c. reversed polarity	Deposits 70–85 Bhn	Weld cast iron and overlay bearing and corrosion resistant surfaces
ECuSn-C[d]	Phosphor bronze (7.0–9.0% Sn)	Same as above	Deposits 85–100 Bhn. Higher yld and ten str than ECuSn-A	Same as above
ENi	Nickel	Arc; flat specified but other positions have been used	Rapid, widely used. Even without preheating, deposits can be machined	Weld ordinary gray irons to themselves or to other ferrous and nonferrous materials; light and medium-sized castings. Reclamation and repair
ENiFe	Nickel-iron	Same as above	Same as above, but higher ten str and ductility	Weld various cast irons to steel and other ferrous and nonferrous materials; heavy and highly stressed sections. Better than ENiFe for castings containing more than 0.20% P
ENiCu-A	Nickel-copper (55–60% Ni)	Same as above	Similar to ENiFe	Similar to ENiFe
ENiCu-B	Nickel-copper (63–70% Ni)	Same as above	Similar to ENi	Similar to ENi
ESt	Mild steel	Arc; a.c. or d.c. reversed polarity	Designated specifically for cast iron; has a low m.p. Covering and deposits not readily machinable	Largely confined to repair of small pits and cracks in cast iron; some larger repairs if casting requires no machining

[a] Chemical symbols for the major elements of the composition are used to classify these rods and electrodes. In other cases, CI = cast iron and St = steel. The letter, or letter and number, following the hyphen indicates a modification of a standard composition.
[b] For exact chemical composition as manufactured, see ASTM A398–56T.
[c] Also a standard classification under Copper and Copper Alloy Welding Rods.
[d] Also a standard classification under Copper and Copper Alloy Welding Electrodes.

Other welding processes. Each process has variants not described and less commonly used. There are also special processes such as *flow welding, forge welding, thermit welding* and *induction welding.* All of these are described in detail in the *Welding Handbook* of the American Welding Society.

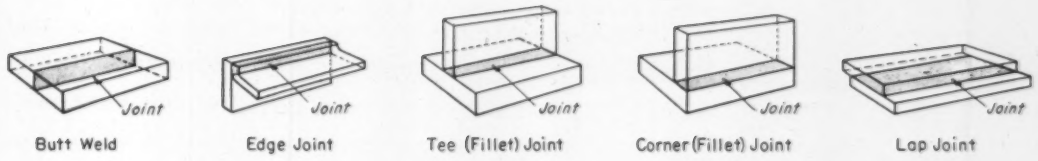


***Fig 1**—The five basic welding joint designs.*

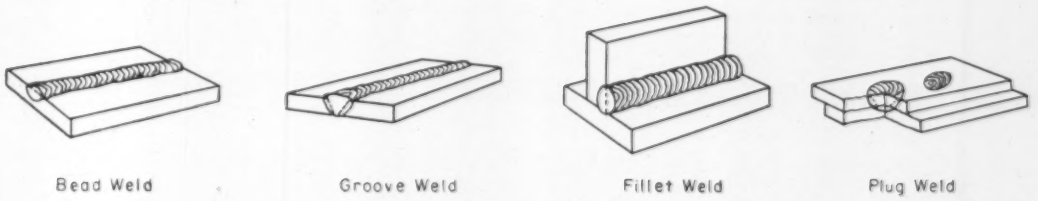


***Fig 2**—The four basic weld types for arc and gas welding.*

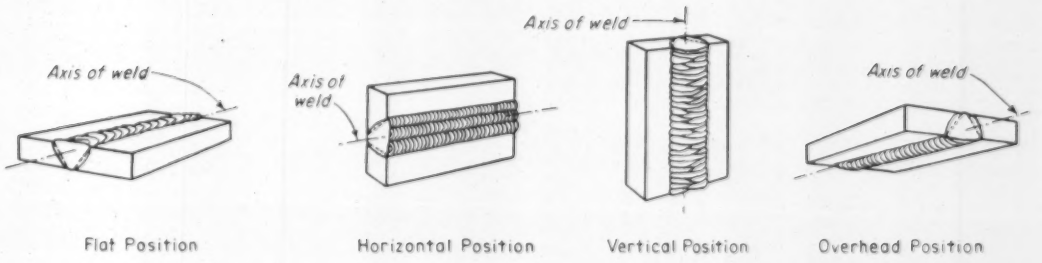


***Fig 3**—The four basic welding positions.*

5—RODS FOR GAS WELDING IRONS AND STEELS [a]

AWS-ASTM Class ↓	Weld Treatment[b]	Min Ten Str, 1000 psi	Min Elong (in 2 in.), %
GA65	SR	65	20
	NSR	72	17
GA60	SR	60	25
	NSR	62	20
GA50	SR	50	28
	NSR	52	23
GB65	SR	65	18
	NSR	72	15
GB60	SR	60	20
	NSR	62	15
GB45	NSR	45	—

[a] Mechanical tests are performed on welds made by either ⅛- or ¼-in. rods and on plates ¾ in. thick (except GB45 which requires a ⅝-in. plate).
[b] SR = stress relieved; NSR = non-stress relieved.

Design Factors

Welding is a basic production method whose end product is a metal part or form termed a "weldment." Weldments must be considered in competition with castings, forgings and other fabricated forms, as well as other joining methods.

Sizes and shapes. A wide range of thicknesses, sizes and shapes can be joined by welding. Parts as thin as 1 mil and as thick as 20 in. have been welded commercially. Plate and sheet stock are the most widely used forms, but forgings, castings, extrusions and rolled shapes are also used in fabricating weldments.

Tolerances. The two principal factors influencing tolerances are distortion from the welding operation and the tolerances of the metal forms that make up the weldment. The tolerances on the various metal forms, such as flat stock, castings, forgings and rolled sections, are easily obtainable. But degree of welding distortion is a function of a great many things, and exact values cannot be given. The following tolerances seem to be those most commonly achieved:

1. Small parts containing very little welding, ⅛ in.
2. Moderately large parts containing a small amount of welding, ¼ in.
3. Large structures containing moderate amounts of welding, ⅜ in.
4. Large, complicated structures, and structures containing large amounts of welding, ⅜ to ½ in.

continued on next page

Welding Electrodes and Rods

6—COPPER AND COPPER ALLOY RODS AND ELECTRODES

AWS-ASTM Class ↓	Common Name	Welding Method[a]	Current, Polarity	Min Ten Str, 1000 psi	Brinell Hardness	Applications
ECu, RCu....	Copper	IGMA (E, R), CA (R), OG (R)	D.c. straight	25	25–40[b]	Light gage Cu up to 3/16 in.—R[c]; heavier gage—E. Deoxidized Cu (R)[e, f]
ECuSi, RCuSi-A....	Silicon bronze (Si 2.8–4.0%)	IGMA (E, R), SMA (E), CA (R), OG (R)	D.c. reverse (E), d.c. straight (R)	50	80–100	Primarily for welding Cu, CuSi and CuZn to themselves (E, R) and to steel (R)[e, f]. Mtl over 1/16 in. thk (E).[d] Silicon bronze; overlay for corr res (E)[g]. CuSi alloys (R)[e]
RCuSi-B.....	Silicon bronze (Si 1.02–2.0%)	CA, OG	D.c. straight	35	60–85	Red brass piping[e]. Cu, CuSi and CuZn[f]; Cu to steel[f]; galvanized iron[f]
RCuSn.....	Phosphor bronze (Sn 4.0–6.0%)	CA, IGMA-NC	D.c. straight	35	70–85	Cu[e, f] and CuSn[e]
ECuSn-A[i]....	Phosphor bronze (Sn 4.8–5.8%)	SMA, IGMA-C	D.c. reverse	35	70–85	Weld phosphor bronzes of similar comp. "A" and "C" (below) used interchangeably for Cu, brasses, bronzes, cast iron, dissimilar metals
ECuSn-C[i]....	Phosphor bronze (Sn 7.0–9.0%)	SMA, IGMA-C	D.c. reverse	40	85–100	Same as above, but "C" provides higher ten and yld str, higher hardness
ECuNi, RCuNi	Copper nickel	SMA (E), OG (R), IGMA-NC(R)	D.c. reverse (E), d.c. straight (R), a.c. (R)	50	60–80	CuNi alloys (10–30%) to themselves to provide good corr res
RCuZn-A[i]....	Naval brass	BW, OG	—	50	70–90	Brass[e]. Cu, bronze, Ni alloys, steel, cast and malleable iron[h]
RCuZn-B[i]....	Manganese bronze	BW	—	55	80–110	Steel and cast iron[h]. As surfacing filler metal for building up bearings
RCuZN-C[i]....	Low-fuming bronze	BW, OG	—	57	80–110	General purpose
RCuZn-D[i]....	Nickel bronze	BW, OG	—	60	90–110	Steel and cast iron[h]
ECuAl-Al, RCuAl-Al...	Aluminum bronze (iron-free)	IGMA (E, R), CA (R)	D.c. reverse (E), a.c. (R)[e], d.c. straight (R)[e, f]	55	100–158 (E), 100–130 (R)[f], 100–150 (R)[e]	Annealed aluminum bronze plate, sheet and strip (E, R). Repair castings (E, R)[e, f]. Overlay bearing and corr res surfaces (E, R)[e]
ECuAl-A2[i], RCuAl-A2[i]	Aluminum bronze (Fe 3.0–4.25%)	IGMA (E, R), SMA (E), CA (R)	D.c. reverse (E)[d, g], d.c. straight (R)[e, f], a.c. (E[g], R[e])	60 (E), 65 (R)	130–150 (E)[g], 150–170 (E)[d], 100–130 (R)[d], 100–150 (R)[e]	Aluminum bronze, high str CuZn alloys, silicon bronze, nickel alloys, ferrous alloys, dissimilar metals. Repair castings; overlay bearing and corr res surfaces
ECuAl-B, RCuAl-B...	Aluminum bronze (Fe 3.0–4.25%)	SMA (E), CA (R), IGMA-NC(R)	D.c. reverse (E), d.c. straight (R)[e, d], a.c. (E, R[e])	65 (E), 70 (R)	140–180 (E), 140–180 (R)[f], 180–220 (R)[e]	Similar to above, but provides higher phys prop. Weld nonferrous metals to steel (E,R)[e]

[a] Method symbols are: IGMA = inert-gas metal arc welding (–C = consumable electrode; –NC = nonconsumable electrode); OG = oxyacetylene welding, CA = carbon arc welding, SMA = shielded metal arc welding (covered electrodes), BW = braze welding.
[b] Rockwell F.
[c] Inert-gas metal arc (nonconsumable electrode) welding.
[d] Inert-gas metal arc (consumable electrode) welding.
[e] Oxyacetylene welding.
[f] Carbon arc welding.
[g] Shielded metal arc welding (covered electrode).
[h] Braze welding.
[i] Also a standard classification under Rods and Electrodes for Welding Cast Iron.

Joint design. There are five fundamental types of arc or gas welded joints (see Fig 1) and four basic types of welds (see Fig 2), but variations of these are used to satisfy particular requirements. Resistance welding commonly employs the lap joint, although flash welding requires a butt joint.

Welding positions. Welds are classified by four basic positions; for each, certain electrodes are recommended or not recommended. The position terms—flat, vertical, horizontal and overhead—can be applied to all types of welds, but they are illustrated here for the groove weld (see Fig 3).

[a] Used with shielded metal arc welding process.
[b] These electrodes are used to join alloys of same composition as the electrode. When first digit of designation is 3, electrode is used primarily to join similar alloys to themselves; when first digit is 4, electrode is used to weld a nickel or nickel-base alloy to steel, to overlay a nickel or nickel-base alloy on steel, or to weld the clad side of nickel or a nickel-base alloy clad steel.
[c] Used to weld not only mill products but also castings of suitable welding quality.
[d] Also used to weld such copper-nickel alloys as 70–30, 80–20 and 90–10 to themselves.
[e] Also used for a number of dissimilar metal combinations.
[f] Age hardened.
[g] Also used to weld alloys of similar composition to steel-clad materials or other metals.

8—NICKEL AND NICKEL ALLOY RODS AND BARE ELECTRODES

AWS-ASTM Class[a] ↓	Alloy	Common Name	Welding Method[b]
RN40	Nickel-copper (Mn 2, Al 0, Ti 0)	Monel	OG[c]
ERN60	Nickel-copper (Mn 1, Al 1.25, Ti 1.50–3.00)	Monel	IGMA, At. H_2
RN41	Nickel (Mn 0.35, Fe 0.40, Ni 97 min, Al 0, Ti 0.50)	Nickel	OG[c]
ERN61	Nickel (Mn 1, Fe 1, Ni 93 min, Al 1.50, Ti 2.00–3.50)	Nickel	IGMA, At. H_2
RN42	Nickel-chromium-iron (Ni 72 min, Cb+Ta 0)	Inconel	OG, IGMA[d]
ERN62	Nickel-chromium-iron (Ni 70 min, Cb+Ta 1.50–3.00)	Inconel	IGMA, At. H_2, OG
RN43	Nickel-copper-silicon	—	OG[e]
ERN64	Nickel-copper-aluminum	K Monel	IGMA, At. H_2[f]
ERN69	Nickel-chromium-iron-titanium	Inconel X[g]	IGMA, At. H_2[f]
ERN6N	Nickel-chromium-titanium	Nimonic 7s	IGMA, At. H_2
ERN7B	Nickel-molybdenum	Hastelloy B	At. H_2, IGMA, Sub Arc
ERN7C	Nickel-molybdenum-chromium (Cr 14.5–16.5, Mo 15–17, W 3.00)	Hastelloy C	At. H_2, IGMA, Sub Arc
ERN7W	Nickel-molybdenum-chromium (Cr 4–6, Mo 23–26, W 0)	Hastelloy W[h]	At. H_2, IGMA, Sub Arc

[a] These rods and electrodes are used to weld alloys of similar composition.
[b] For the IGMA process, argon and d.c. reversed polarity are preferred for electrodes; either argon or helium and d.c. straight polarity with rods. Welding method symbols used are: OG = oxyacetylene; IGMA = inert-gas metal arc; At. H_2 = atomic hydrogen; Sub Arc = submerged arc.
[c] Gross porosity usually results when arc welding is employed.
[d] Do not use inert-gas metal arc method on sheet ⅛ in. thick and heavier.
[e] Used to weld monel which has 55–60% Ni, or any monel when absence of flux desirable.
[f] Responds to age hardening.
[g] Used to weld Inconel X and Inconel W.
[h] Used to weld such dissimilar metal combinations as Cr-Ni-Fe steels to cast cobalt alloys.

7—NICKEL AND NICKEL ALLOY COVERED ELECTRODES[a]

AWS-ASTM Class[b] ↓	Alloy	Common Name	Min Ten Str, 1000 psi
E3N10	Nickel-copper (C 0.40, Mn 4, Cb+Ta 0%)	Monel[c,d]	70
E3N11	Nickel (C 0.75)	Nickel[c]	55
E3N12	Nickel-chromium-iron	Inconel[c]	80
E3N14	Nickel-copper-aluminum	K monel[c]	100[f]
E3N19	Nickel-chromium-iron-titanium	Inconel X	115[f]
E3N1B, E4NiB	Nickel-molybdenum	Hastelloy B[g]	100
E3N1C, E4NiC	Nickel-molybdenum-chromium	Hastelloy C[g]	100
E4N10	Nickel-copper (C 0.15, Mn 2.50, Cb+Ta 3%)	Monel	—
E4N11	Nickel (C 0.10%)	Nickel	—
E4N12	Nickel-chromium	Inconel	—

9—ALUMINUM AND ALUMINUM ALLOY RODS AND ELECTRODES

AWS-ASTM Class ↓	Major Composition As Manufactured	Alloys Welded[a]
BARE ELECTRODES AND RODS[b]		
R-996A, E-996A	Al 99.6 min	996A
R-990A, E-990A	Al 99.0 min	990A, M1A, G1A, clad M1A
R-C4A	Cu 4.0–5.0	CS42A, C4A
R-CN42A	Cu 3.5–4.5, Ni 1.7–2.3	CN42A
R-CS41A, E-CS41A	Cu 3.9–5.0, Si 0.50–1.2	Clad CS41A
R-G1A, E-G1A	Mg 1.0–1.8	M1A, G1A, clad M1A
R-GM50A, E-Gm50A	Mg 4.9–5.6, Mn 0.05–0.20	MG11A, Gr20A, clad MG11A, GS42A, GS11A
R-GR20A, E-GR20A	Mg 2.2–2.8, Cr 0.15–0.35	MG11A, GR20A, clad MG11A
R-GR40A, E-GR40A	Mg 3.1–3.9, Cr 0.15–0.35	MG11A, GR20A, GS11A, clad MG11A, GS42A, GR40A
R-MG11A, E-MG11A	Mn 1.0–1.5, Mg 0.8–1.3	MG11A, clad MG11A
R-S5B, E-S5B	Si 4.5–6.0, Bi 0.05	M1A, MG11A, G1A, GR20A, CS11A, clad M1A, clad MG11A, S5A
R-SC51A	Si 4.5–5.5, Cu 1.0–1.5	SC51A
R-SG70A	Si 6.5–7.5, Mg 0.20–0.40	SG70A
R-ZG61A	Zn 5.2–6.0, Mg 0.50–0.65	ZG61A
COVERED ELECTRODES[c]		
Al-2	Al 99.0 min	Pure aluminum (min ten str 12,000 psi)
Al-43	Si 4.5–6.0, Al bal	General purpose (min ten str 14,000 psi)

[a] These ASTM alloy designations apply to all forms except die castings.
[b] Welding methods include gas, shielded carbon arc, inert-gas metal arc and atomic hydrogen.
[c] Used with d.c. current, preferably in flat position.

Adhesives

Selection

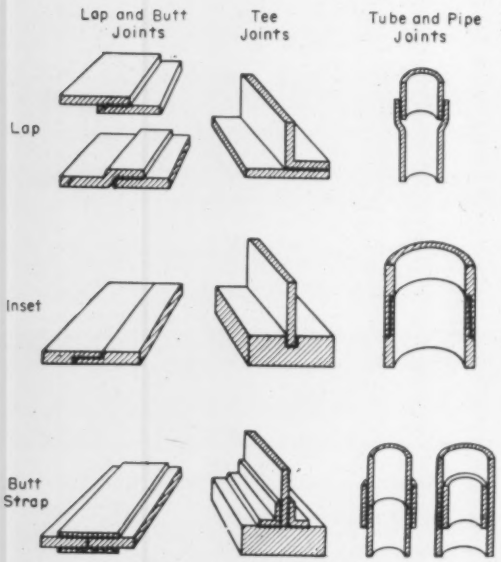
Classification. There are many ways to classify adhesives, none of which is satisfactory by itself. The five tables included here, each using a different breakdown, must therefore be referred to as a group. Classifying by chemical composition (Table 1) is most usual, but the newer modified compounds are omitted because they represent the blending of several chemical groups, and because the use of tradenames often obscures the chemical designation. In addition, in only a limited sense is the relationship between the type of materials being joined and the chemical type of the modified compounds a factor in selecting the adhesive.

These new adhesive "alloys" include: phenolic elastomers (e.g., phenolic-neoprene, phenolic-Buna N); vinyl phenolics (phenolic-vinyl, phenolic-polyvinyl butyral, phenolic-polyvinyl formal); modified epoxies (epoxy-phenolic, epoxy-polyamide, epoxy-polysulfide).

The other four tables apply to the single-resin adhesives as well as to these new modified compounds. In addition there are two factors which must be given more attention than the tables indicate:

Time. All classifications (as well as tack and bond strength properties) are related to time in various ways—shelf and pot life, tack life, length of time of application of heat and pressure, time lapse before handling parts, time lapse before end service.

End service conditions. Only by knowing and considering all the factors of end service, as well as all factors discussed in the tables here, can the formulator recommend a particular chemical composition with particular bonding requirements, vehicle, form and flowability. New formulations are devised where necessary. Also, it is not uncommon to use *two* adhesive formulations (allowing the first to dry before applying the second) to obtain the desirable advantages of each, or to obviate an undesirable effect of contact between the second adhesive and the surface.



***Some examples** of good joint design.*

Definitions

Emulsion. Adhesive type in which basic resin is a water-insoluble liquid (or solid particles) stably dispersed in water. Emulsifying agents are added to decrease surface tension. Some emulsions also contain a small amount of solvents (5%) to increase tackiness and improve water resistance.

Glue line thickness. Thickness of the fully dried adhesive layer.

Lay down thickness. Thickness of the applied wet adhesive coating.

100% reactive. Also "100% solids." Generally a modified epoxy resin-base paste, this adhesive type contains no solvent and cures at room temperature or higher.

Pot life. Length of time adhesive remains usable after being put into serviceable condition.

Shelf life. Length of time adhesive can be stored without deterioration (also known as "can stability").

Solvent dispersion. Adhesive type in which basic resin is in solvent solution and bonding is done by evaporation of the solvent (solvent release). A wide variety of solvents are used: ketones, toluol, naphtha, hydrocarbons, alcohol, acetone, etc. Solvent content generally varies from 10 to 50% for thermoplastic and thermosetting adhesives, from 50 to 95% for elastomeric.

Tack. The charateristic ("stickiness") that causes one surface, coated with adhesive, to adhere to another upon contact. Tack time may range from a few seconds to an almost indefinite period.

Wet strength. The bond strength realized immediately after adhesive-coated surfaces are joined and before cure occurs.

Methods

Adhesive bonding lends itself to complex automatic set-ups using spray guns, flow guns, paint rollers, etc. to apply the adhesive; pressure rolls, heavy presses, ovens, autoclaves, etc. to develop the bond. However, hand bonding with solvent-dispersed adhesives is common, and an understanding of the five steps involved can be applied to other methods:

1. **Surface preparation**—Surfaces should be smooth; must be clean and dry. Precleaning generally involves abrasive or chemical cleaning (ceramics, metals), light sanding (wood), chemical removal of mold release or plasticizer bloom (rubber, plastics), etc.

2. **Adhesive preparation**—Placing adhesive in a serviceable state may require mixing, thinning, reactivating, etc.

3. **Applying adhesive**—Varies from sticking coated film or tape or nameplate in place to use of trowel, squeeze bottle, hand roller, brush, etc.

1—CLASSIFIED BY CHEMICAL COMPOSITION GROUP

Type →	Natural	Thermoplastic	Thermosetting	Elastomeric
Examples of Type	Casein, blood albumin, hide, bone, fish, starch (plain and modified); rosin, shellac, asphalt; inorganic (sodium silicate, litharge-glycerin)	Polyvinyl acetate, polyvinyl alcohol, acrylic, cellulose nitrate, asphalt, oleoresin	Phenolic, resorcinol, phenol-resorcinol, epoxy, urea, melamine, alkyd	Natural rubber, reclaim rubber, butadiene-styrene (GR-S), neoprene, acrylonitrile-butadiene (Buna-N), silicone
Most Used Form	Liquid, powder	Liquid, some dry film	Liquid, but all forms common	Liquid, some tape
Common Further Classifications	By vehicle (water emulsion is most common but many types are solvent dispersions)	By vehicle (most are solvent dispersions or water emulsions)	By bonding requirements (heat and/or pressure most common but some are catalyst types)	By bonding req (all are common). Also by vehicle (most are solvent dispersions or water emulsions)
Bond Characteristics	Wide range, but generally low strength; good res to heat, chemicals	Good to 150–200 F; poor creep strength; fair peel strength	Good to 200–500 F; good creep strength; fair peel strength	Good to 150–400 F; never melt completely; low strength; high flexibility
Major Type of Use	Household, general purpose, quick set, long shelf life	Unstressed joints; designs with caps, overlaps, stiffeners	Stressed joints at slightly elevated temp	Unstressed joints on lightweight materials; joints in flexure
Materials Most Commonly Bonded	Wood (furniture), paper, cork, liners, packaging (food), textiles, some metals and plastics. Industrial uses giving way to newer types, esp in woodworking	Formulation range covers all materials, but emphasis on nonmetallics, esp wood, leather, cork, paper, etc., because these are less likely to require stressed joints	Depends greatly on specific type: epoxies for dissimilar materials and plastics; phenolics for metal, glass and wood; ureas and melamines extensively for wood; alkyds for metal laminations.	Few used "straight" for wood, rubber, fabric, foil, paper, leather, plastics films; also as tapes. Most modified with synthetic resins

2—CLASSIFIED BY BONDING TYPE[a]

General Type ↓	Specific Types Available[b]	Forms Used	Remarks
Heat	Rm temp to 450-F types available; 250 to 350-F types most common	Formulated in all forms; liquid most common	Applying heat will usually increase the bond strength of any adhesive, even rm temp types
Pressure	Contact to 500-psi types available; 25 to 200-psi types most common	Formulated in all forms; liquid + powder most common	Pressure types usually have greater strength (not true of modified epoxies)
Time	Types requiring a few seconds to a week available; ½ to 24-hr types most common	Formulated in all forms	Time required varies with pressure and temp applied and immediate strength
Catalyst	Extremely varied in terms of chemical catalyst required; may also contain thinners, etc.	Two components—paste (or liquid) + liquid	Sometimes catalyst types may require elevated temp (<212 F) and/or pressure instead of, or in addition to, a chemical agent
Vulcanizing	Varied types requiring addition of a chemical agent (usually sulfur); may also contain a catalyst	Two liquid components	Premixed types requiring 250 to 350 F for vulcanization are available
Reactivation	Types requiring heat or solvent or second coating of adhesive	Dry film or previously applied liquid	Heat type is best for nonporous surfaces and/or max strength

[a] Formulations may be a combination of two or more of these types.
[b] Types stated as being most common refer to modified or "alloy" adhesive compounds.

4. Assembly—Accomplished during tack life of adhesive (5 min to 1 hr for porous surfaces, but can be extended) or after reactivating dried coating.

5. Bond development—Drying out of the solvent usually takes 1 to 60 min. Heat can be applied by warm air, infrared lamps or hot plate; pressure by

Adhesives

3—CLASSIFIED BY VEHICLE[a]

Type ➡	Solvent Dispersion	Water Emulsion	100% Reactive ("100% solids")
Form	Liquids, pastes, tapes, supported films	Liquids	Pastes, films
Adhesive Alloy	Elastomer (rubber or vinyl butyral) + thermosetting resin (phenolic, sometimes epoxy or alkyd)	Reclaimed rubber + asphalt; milk latex	Usually modified epoxies (others for films)
Bonding Requirements	Usually pressure and/or heat, solvents (reactivation type)	Heat and/or pressure	Contact pressure; choice of rm temp or heat curing
Advantages	Flowability; easy to apply in film or tape form and from dispensing bottles. Can be reactivated after drying. Allows widest choice to formulator	Most inexpensive of the three. Eliminates fire hazard. Consistency can be varied by adding water	No time wait for solvent release. Eliminates fire hazard. No attack on vulnerable adherends. High heat resistance. Fills voids
Limitations	Care must be taken to allow for solvent release if both surfaces are nonporous (not usually recommended). Solvent may interact unfavorably with certain plastics	Usually limited to bonding where at least one surface is nonporous. Some types require high pressure. Freezing damages bonding properties	Peel, stretch and impact properties not usually as high as in others. Not freely flowing. Usually supplied as two-component adhesive requiring mixing. High shear strength falls rapidly above specified temp
Remarks	Elastomer adds flexibility, peel and impact strength	Curing characteristics highly influenced by added modifiers	Highly suited for metal-to-metal bonds, electrical uses

[a] This method of classification is the most common for modified compounds, but omits "contact-bond" and "pressure-sensitive" adhesives. Contact-bond adhesives adhere to themselves for a specified period of time after the coating has dried. Pressure-sensitive types adhere to almost any surface for an almost indefinite period of time after drying.

4—CLASSIFIED BY FORM

Type ➡	Remarks	Advantages
Liquid	Most common form; practically every formulation available. Principally solvent-dispersed	Easy to apply. Viscosity often under control of user. Major form for hand application
Paste	Wide range of consistencies. Limited formulations; principally 100% solids modified epoxies	Lends itself to high production set-ups because of less time wait. High shear and creep strengths
Powder	Require mixing or heating to activate curing	Longer shelf life; mixed in quantities needed
Mastic	Applied with trowel	Void-filling, nonflowing
Film, tape	Limited to flat surfaces, wide range of curing ease	Quick and easy application. No waste or runover; uniform thickness
Other	Rods, supported tapes, precoated copper for printed circuits, etc.	Ease of application and cure for particular use

5—CLASSIFIED BY FLOWABILITY[a]

Type ➡	Form or Vehicle Type	Advantages
Flow	Liquid, light or heated pastes, solvent dispersion, water emulsion	Fills crevices, fills complex joints, evens glue line, smooths surface
Nonflow	Heavy paste, trowelable mastic, void-filling epoxy, 100% solids	Applies vertically, requires no "clean-up," fills voids and gaps, does not sag

[a] There is no fine line of distinction between these types. In addition, flowability is affected by such factors as: temperature, pressure, joint design, time left standing, mixing of catalysts or solvents.

weighted hand rollers, metal weights or squeeze rolls. With nonporous surfaces, solvent must be dried out before final assembly pressure; for such application heat reactivation types are often used (applying heat and/or pressure after assembly of dried coated parts), but stronger bonds are developed by using 100%-reactive adhesives rather than solvent-dispersed.

Joint Design

Joints should be designed to keep the adhesive in shear and avoid cleavage and peel stresses. Typical good joint designs are shown by the accompanying sketches.

The type of strength under consideration (particularly peel vs shear) is extremely important in adhesive bonding.

Joint properties are also a function of the thickness of the glue line. Shear and creep strength are highest for thin films (0.001 to 0.003 in.), but heavier films may exhibit higher flexibility, toughness and cleavage strength.

Because there are so many factors involved in adhesive selection, compromise may be necessary. To aid the formulator in making this compromise, and to minimize cost, safety factors included in specifications should be only as high as absolutely necessary.

Mechanical Fasteners

Mechanical fastening is the most versatile and most widely used method for joining materials and parts. In the broadest sense, mechanical fasteners can be classified in two groups: threaded types (semipermanent) and rivets (permanent).

Threaded Fasteners

Types. The accompanying table describes the most common types of threaded fasteners (including washers). Some other types include:

Screws—In addition to variations (e.g., spanner heads, wing heads, split points), of every screw described, there are many special types, such as: sealing, twin head, one-way set and load-indicating.

Bolts—Many special head variations are available for the bolts described. Two important types not listed are sealing bolts (designed with an integral rubber washer under the head) and blind bolts (expander nut pulled back into sleeve by hydraulic gun, then core bolt inserted). Still more specialized bolts include: track, blow, tap, bent, load-indicating, crating, rib, and drive and locking stud bolts.

Nuts—There are nuts to mate with almost every type of bolt described. Other types include: acorn, anchor, clinch weldments (attached by spot welding), roofing, wing or thumb, and grommets.

Washers—Special types include: countersunk, sealing, sleeve, load-indicating, pipe and laminated.

Thread series. Most common threads are designated "Unified and American" and are either "coarse" or "fine," depending on the number of threads per inch for a specific diameter. The coarse series is for general use where quick assembly is desired; the fine series for aeronautical and similar work. Other series (e.g., 8-thread), as well as other standards (e.g., Whitworth), are in use.

Thread class. Class refers to the tolerance in manufacture and to the allowances permissible. The majority of screws and bolts are produced to class 2A (external tolerances and positive allowances); nuts to 2B (internal tolerances). Where closeness of fit is required, classes 3A and 3B may be used. Various fits are obtained by combining male and female threads of different classes.

Materials. Although the use of low carbon steel is widespread, all common metals, as well as some thermoplastics, are used in critical applications. To obviate galvanic corrosion, it is often desirable to use fasteners made from a material similar to those being joined. However, the corrosive effect must be weighed against such factors as increased strength and greater holding power.

Screws—Carbon and stainless steels, brass, silicon bronze and aluminum are often standard or available on order. Special materials available in limited types include die cast zinc alloys and several thermoplastics (nylon is most common). Zinc and cadmium-plated screws are often standard, and other electroplates are available on order. Other finishes and coatings include anodized, carbonized and black oxide.

Bolts and nuts—Carbon, alloy and stainless steels are standard for almost every type, but brass, naval bronze, monel and aluminum are often standard as well. Special materials available in some types include: malleable iron, silicon bronze, titanium, sintered brass, nylon and other thermoplastics. Finishes and coatings include those available for screws. Nuts, however, are often supplied with one of the following additional finishes: nickel and silver-plated, molybdenum disulfide, chromate, phosphate, and chromium oxide diffusion.

Washers—Most standard nut materials are also used for washers. Special materials include chromium-molybdenum steel, galvanized steel, vulcanized fibre and extruded nylon. Sealing washers generally are rubber—natural, silicone, neoprene or nitrile. Standard electroplated finish is usually cadmium, but zinc, nickel, tin, copper and chromium are not uncommon. Other finishes include phosphate and oil.

Design. Details of design depend upon many factors, including the type, style and material of the fastener which has been selected after consideration of end service conditions, materials being joined, speed and ease of assembly required, and ease and frequency of disassembly required. Loading should be in shear rather than tension. When assembly of the fastener requires that pressure, sharp blows or torque be applied to one side of the joint, that side should be the one having the thicker or harder material.

Descriptive nomenclature. Threaded fasteners are available with many types of shanks, heads, locking devices, etc.—some standardized and many not—which makes it impractical to define the hundreds of terms used. In addition, fastener terminology is apt to be overlapping, making it difficult, in theory, to distinguish between such items as bolts and screws, or machine screws and certain cap screws. Recent standards, for instance, include stove bolts with machine screws.

In the accompanying tables types have been distinguished according to general practice, rather than theory, as much as possible. In addition, the word "top" has been coined. Industry uses the word "head" for two purposes: to refer to the shape (generally as viewed from the side), and to refer to the design for a particular tool (generally recognizable by viewing from the top). The word "top" used in the tables refers to the latter. For example, a slotted round head (round as viewed from the top and slotted on top for a conventional screwdriver) is listed here as: top—slotted, head—round.

Rivets

Riveting is the fastest production fastening method of producing fairly strong joints with unskilled labor, yet with a high degree of consistency. Rivets are driven either hot or cold, by hammering or peening or by applying steady pressure from one or both sides. The shear strength of solid rivet joints is equal to or higher than that of most common threaded fasteners. Tubular and split are lower in strength, particularly tensile.

Design factors are similar to those for threaded fasteners. Joints are either lap or butt (using butt strap). Minimum recommended rivet spacing is usually three times the body diameter of the rivet. Allowable distances from edges are usually based on the rivet body diameter; 1½D for hot-driven rivets and 2D for cold-driven.

Materials from which rivets are fabricated include iron, low carbon steel, stainless steel, brass, copper, monel, aluminum, nickel silver and several thermoplastics. Coatings and finishes of all types can be ordered.

The table on p 453 describes the most common types of rivets.

tables start on next page

Mechanical Fasteners

THREADED FASTENERS—SCREWS

Type ↓	Description	Made of . . .	Selection Features	Uses
Wood	Top—slotted or cross-recessed. Head—flat, round or oval. Thread—single, some double; point—gimlet. Also drive screws, hanger bolts, dowel screws	Low and medium carbon steels; alloy and stainless steel, monel, others	General use	Wood, and thin sheets of other material to wood
Cap	Top—hex or fluted socket; head—smooth or knurled. Top—slotted; head—round, flat, fillister or hex. Thread—coarse or fine; 8-thread; point-chamfer. Also top—plain; head—hex or knurled	Carbon and stainless steel, brass, bronze, monel, aluminum	General use with tapped holes or nuts. Shank usually not fully threaded. Socket type (most used) has closer fit than machine screws	Fastening metal parts and components
Machine	Top—slotted or cross-recessed; head—round, flat, oval, undercut (flat or oval), fillister, truss, binding or pan. Also hex heads, tops plain or slotted. Thread—coarse or fine; point—sheared	Carbon and stainless steel, brass, silicon bronze, monel, aluminum	Same as cap, but usually full-thread shank and smaller dia. Slotted type most used, generally with nut	Same as cap
Tapping (thread-forming)	ASA "A": Top—slotted or recessed; head—flat, oval, round, pan, fillister, truss or hex; thread—spaced; point—gimlet. "B": Same but blunt point. "BP": Same but cone point. "C": Same but blunt tapered point and machine thread	Case hardened steel; others on special order	A—general sheet metal screw; B—heavier duty; BP—misaligned parts; C—higher strength	All—Sheet metal, wood, asbestos, cloth to sheet metal. C—Cast iron, die cast zinc, steel, bronze and brass forgings, plastics
	Drive screws. 1) Top—plain; head—round; point—dog; thread—multiple with large helix angle. 2) Top—plain; head—pan; point—cone; thread—annular in upper section, but lower section has multiple threads with large helix angle	Case hardened steel; others on special order	Forms mating thread as hammered or pressed; can be applied with hopper-fed machines	Permanent fastenings. 1) Castings, heavy-gage sheet, plastics. 2) Fabric, leather or fiber to sheet metal
Thread-Cutting	ASA "D", "F", "G" and "T": Top—slotted or recessed; head—flat, oval, round, pan, truss or hex; thread—machine; point—blunt. Types differ in cutting edge: D—one off-center slot; F—several flutes; C—one centered through-slot; T—one wide slot. ASA "BF", "BG" and "BT" similar to F, G and T, respectively, but have spaced thread	Case hardened steel; stainless steel on special order	Minimum driving torque; fewer chips; increased resistance to stripping out	As above, but thin sections, particularly bosses in brittle plastics, plywood
Lock	Various proprietary types, such as: 1) preassembled lead washer; 2) variation of A.N. thread form; 3) longitudinal insert; 4) nylon pellet insert; and 5) annular expansion insert. Other types include: preassembled screw and lock washer, screw with locking teeth under head, slotted head fitting into counterbored hole with insert forced into slot. Also, liquid sealants used with standard screws	1—Heat treated alloy steel. 2—All std screw mtls. 3—Steel (incl stainless), brass, aluminum; insert is fluorocarbon plastic. 4—Carbon and stainless steel, aluminum alloy, brass, bronze. 5—Heat treated alloy steel; insert is bronze	1—Washer extrudes around tapered head. 2—Locks on full length of thread by reforming mating thread. 3—Insert does not project, has gradual torque build-up. 4—Insert projects slightly, locks whether or not screw is seated. 5—Insert expands when compressed, remains when screw is removed	Widely used, esp in mass production. Various types allow joining all metals and many plastics. Particular use depends on such factors as: permanent or disassembly; ease of assembly; amount of torque to assemble or disassemble; type of stress—rotational, vibration, thermal; sealing properties

THREADED FASTENERS—BOLTS AND NUTS

Type ↓	Description	Made of . . .	Selection Features	Uses
Regular (general use)	External hexagon or square head, generally used with nut of same shape. "Regular"—unfinished (not machined on any surface except threads); coarse threads. "Regular semifinished"—bolt heads and nuts are machined on bearing surface to provide washer face (or nuts may have chamfered corners); coarse threads. "Finished"—same as regular semifinished but closer body tolerance; threads—coarse, fine and 8-thread. Std. machine screw nut is "regular"	Carbon and alloy steel, stainless steel, brass, naval bronze, monel, aluminum	Longer bolts are similar to hexagon cap screws, shorter to hexagon machine screws, but the hex head is more common with bolts, as is the use of nuts. Bolts come in greater standard lengths, are sturdier and are classified differently	Widely used for all materials. For larger parts and greater stresses than screws. Where material too soft or hard, or too thin, to be tapped. Where threaded shanks easily accessible
Jam Nut	Similar to Regular or Heavy, but thinner	Same as above	Higher shear str; lower ten str than above	Often used with full nut for locking action
Lag Bolt	Head—square; point—gimlet or cone. Also known as lag screw	Low carbon steel	—	Fasten wood together or any material to masonry
Round Head Bolt	Two body styles (std dia and undersized) with coarse threads. Bolts include: 1) round head, square neck; 2) round head, short square neck; 3) round head, ribbed neck; 4) round head, fin neck; 5) 114-deg-countersunk square neck; 6) round head; 7) elevator (flat, large dia head; square neck); 8) ribbed head—slotted and unslotted; 9) step (like elevator but round head); 10) countersunk	Carbon and alloy steel, stainless steel, brass, naval bronze, monel, aluminum	These bolts differ in the method used to prevent rotation during bolting. Each is inserted in a hole which mates with the neck. Head types are selected by appearance or need for flush tops	For 1) wood, 2) steel, 3) hard wood and plastics, 4) wood, 5) wood, 6) any material where there is no other way to prevent rotation, 7) soft materials, 8) flooring, 9) resilient materials to steel, 10) metal to wood
Stud Bolt (stud)	A stud is a rod threaded either completely or on both ends. Types include: tap end (one end to produce interference fit in tapped hole, other for nut); double end (both ends for nuts); continuous thread; hangar bolt (one end has lag screw thread)	Low carbon steel	Advantageous where length adjustment desirable	Widely used for castings (permanently assembled) and for soft metal and plastic parts
Place Bolt	Flexible zone is formed by slotted segments in the upper face of a hex bolt head and a circular recess in the lower face, providing a controlled spring action which increases elastic elongation	Carbon and alloy steel; others available	Provides resistance to loosening by vibration and minimizes fatigue failure	Cylinder heads, flywheel housings, bearings (cap screw), connecting rods
Locknut	Huge variety of proprietary locknuts, most of which can be classified as one of the following types: 1) free-spinning (no locking action until seating begins, e.g., integral toothed washers), 2) prevailing torque (locking depends on some form of interference between male and female threads, e.g., deforming threads or forcing lead or angle), 3) spring action (designed to take advantage of natural spring of the material or with auxiliary springs, e.g., slotted segments; arched base with prongs to lock against threads)	Nuts—carbon steel generally std; also stainless, brass, monel, aluminum. Springs—heat treated spring steel usually std; also stainless, brass, phosphor bronze, beryllium copper. Inserts—bronze usually std; also brass, aluminum, steel	Locknuts remain tight under vibration and replace the use of wire or cotter pins in a hole drilled through bolt and nut. Each type designed for specific use in terms of materials, end service conditions, ease of assembly, etc.	Mass produced automobiles, appliances, machinery, aircraft, furniture, toys, etc.

continued on next page

Mechanical Fasteners

THREADED FASTENERS—WASHERS AND INSERTS

Type ↓	Description	Made of . . .	Selection Features	Uses
Plain Washer	Plain, flat, circular washer standardized in o.d. and i.d. dimensions (ASAB27.2–1953) and with suggested thicknesses. Form series are: light, medium, heavy, extra heavy	Almost all materials used for nuts	Provide increased bearing surface for bolt heads or nuts, thus distributing load over larger area. Also prevent marring, improve appearance	Widely used with nuts and bolts
Lock Washer	Split spring type. Washer is split and shaped like a single turn of a slight helix. Free height is about twice the washer thickness; gap is small enough to prevent entangling. Same four series as plain washers	Carbon steel, stainless 302 or 420, aluminum-zinc alloy, phosphor and silicon bronze, K monel. Not all materials in all four series	Prevents loosening of bolt under vibration. Split-spring type allows occasional disassembly and reassembly; tang of helix may mar work surface	Widely used for most plain threaded screws and bolts
	Tooth type. Teeth on i.d., o.d. or both. Variety of shapes and tooth types designed for specific uses	Carbon steel, phosphor bronze	Same as above, but thinner than split-spring, not recommended for frequent disassembly	External tooth type for bolts; internal tooth type for screws
	Spring type. Some proprietary types: domed, conical, waved, countersunk, cap, folded rim, tab, irregular hole, wood spring	Medium carbon and stainless steel, bronze, aluminum, beryllium, copper, K monel	Provides strong locking with varied other features	Special uses, generally on softer materials
Insert	May be threaded bushings, studs, etc, cast or molded integrally with part. Many proprietary inserts are molded in or inserted after part is formed. Noncircular cross sections resist turning; undercuts resist tensile pull. Some types are: 1) slotted body, exterior fins, 2) slotted and tapered body containing four-eared disk below threaded portion, 3) spool-shaped spacer, 4) helical coil of diamond-shaped wire (also locking type with center loop of coil octagon-shaped), 5) disk-shaped with edge groove around middle, 6) threaded, with embedded nylon pellet, 7) two-piece: threaded insert and lock ring	1) Aluminum alloy, 2) brass, 3) aluminum alloy, 4) stainless, phosphor bronze, Hastelloy C, 5) brass, steel, stainless, aluminum, 6) low carbon steel, 7) low carbon steel. Most inserts can be obtained in other materials, e.g., brass, bronze, aluminum, monel	Added strength for soft materials. 1) Allows expansion pressure against hole and screw. 2) Disk is forced down to spread four tapered segments. 3) Through-bolt or threaded. 4) Coil has both internal and external thread; inserted in tapped hole. 5) Locked by swaging tool. 6) Uses standard screwdriver. 7) Outer teeth of lock ring broach into parent material	Limited to parts thick enough to hold insert. 1) Wood, plastics, soft metals. 2) Replace molded-in inserts. 3) Sandwich panels. 4) Where weight and wear are problems; used in damaged tapped holes. 5) Plastics sheet, soft sheet metal. 6) Nonferrous metals. 7) Hard materials (resists vibration and stress); soft materials (resists wear)

RIVETS, STITCHING AND STAPLING

Type ↓	Description	Uses
RIVETS		
Large Solid	Dia from ½–1¾ in. Head—button, high button, cone, pan or countersunk (flat or round). Neck—straight or swell (exc countersunk). Special heads include: machine, globe, wheel, trunk. Wrought iron and steel are std mtls; others available	High production, permanent assembly operations requiring high tensile and shear strength and generally not requiring airtight or watertight joints. Aircraft, ships, trains, bus and truck bodies, etc.
Small Solid	Head—flat, countersunk, button, pan, truss, tinners', coopers' or belt	As above (generally cold riveting is used on small rivets, hot riveting on large)
Semi-Tubular	Shallow hole, extruded or drilled in shanks, does not exceed shank dia. Variety of heads include: oval, flat countersunk, tinners', cone	Where stress is low, or primarily shear. Metals, ceramics, hard plastics and woods; through predrilled or prepunched holes. Aircraft, cameras, toys
Tubular	Hole in shank is deeper than dia but less than ½ in. Rivet compresses material within shank. Head variety same as above	Where stress is low, or primarily shear. Leather, soft plastics, rubber, soft woods, fabrics. Leather cases, golf bags, sheet metal
Split	Slot milled in shank forms two sharp prongs that pierce material without weakening it	Where stress is low, or primarily shear. Light-gage metal, plastics, wood, fibreboard, leather
Shouldered	Shoulder beneath head is made to spec. Either coldformed or coldheaded and turned	Where pivot or bearing surface req within joined members. Automotive parts, vending machines
Blind	Proprietary types, of which most are one of these: 1) sleeve—either hollow (mandrel pulled back through; may be plugged if desired), or self-plugging (after mandrel is pulled through it is trimmed off to leave solid rivet); 2) pin driven through tapered hole in rivet to expand it, then lip peened over pin head; 3) type for which a special assembly tool is basic, e.g., a gun grips pull-through mandrel, clinches rivet, continues to pull until head or stem breaks; 4) explosive charge contained within shank is detonated (by riveting iron, etc.) to expand rivet to fill hole and form bulb on end. Materials are: cadmium-plated steel, aluminum alloy, brass, stainless, monel, etc.	Where backing up the rivet is impractical, usually due to inaccessibility. 1) Lends itself esp to automatic setting; hollow is not as strong but can be plugged by any mtl desired and with umbrella head to match design. 2) High shear str, good ten str. 3) High assembly rate; rivet has high str clinch but is not completely hole-filling. 4) Extremely high assembly rate; widely used to fasten both metals and nonmetallics; nearly equiv in str to solid rivet
Other	Some special rivets are: outside prong, compression, decorative spot, precious metal, brake lining	Special uses
METAL STITCHING AND STAPLING		
Stitching and Stapling	Joining two or more materials with 18-gage wire fed from a coil, cut to length, formed, driven through and clinched. High assembly rate, but limited to thin parts, e.g., joining 0.093-in. aluminum strips. Loop clinches are best for nonstructural joints, flat clinches for stressed. Stapling differs in using preformed fasteners. Std mtls include high carbon steel, stainless, and phosphor bronze	For sheet and strip stock of all materials, but preferably joining soft nonmetallics to metal. Also sandwich materials

Characteristics of typical Raybestos-Manhattan Ray-BOND® Adhesives

NUMBER	TYPE	CHARACTERISTICS	USES
R-81001 R-81002 R-81008	Thermosetting synthetic rubber, synthetic resin; heat setting. Solids range from 18 to 40%.	Flexible, resistant to oils, solvents; requires heat and pressure for cure.	For bonding metals, plastics, friction materials to themselves or to each other. Not recommended for use on assemblies where bond line temp. might exceed 400°F for prolonged periods in application. Short term to 600°F.
R-82004	Synthetic rubber, synthetic resin; emulsion adhesive; cold setting; solvent evaporation type.	Flexible, good peel strength, medium drying; gains strength upon loss of solvent; exhibits good strength up to 270°F for nonstructural applications.	For bonding nonporous or semiporous materials to themselves and to various metals—plastics, decorative metal parts, leather, etc.
R-82005 R-82006 R-82007 R-82008	Synthetic rubber, synthetic resin; solvent evaporation type. Solids range from 17 to 30%.	Flexible, good peel strength, quick drying; gains strength upon loss of solvent; not to be used on parts that might be subjected to temperatures in excess of 180°F; sprays well.	General laminating adhesive for plywood, chipboard, hardboard, paper and metal honeycomb, composition base materials to each other or to rigid plastic and metal.
R-82013	Synthetic rubber, synthetic resin; cold setting or heat setting.	Flexible, good peel strength, quick drying; gains strength upon loss of solvent.	General-purpose adhesive for nonstructural parts. Vinyl (PVC) to plastic, metal, cloth, and buna-N type rubbers to metal or to themselves.
R-84001 R-84002	Synthetic resin; hot melt type.	Flexible, to be heated to 250-300°F and applied. Strength obtained upon cooling. Ball and ring melt test, 205°F.	General purpose adhesive for bonding most materials including mylar and polyethylene. Recommended as a nonstructural adhesive for applications where the bond line temperature will not exceed 200°F.
R-84029	Synthetic resin; heat setting.	Heat resistant to 650°F; some degree of flexibility; resistant to oils, solvents, water, brake fluids.	For bonding friction material to friction material or to steel where some degree of flexibility is desired.
R-86008	Synthetic resin; 2-component system.	Good electrical properties, low shrinkage. Heat distortion point of 178°F. Pot life 30 min.	Casting, encapsulating and potting. Metal to metal, ceramic to metal, glass to metal.
R-86009	Synthetic resin; 2-component system.	Salt water resistant; semi-flexible; room temperature curing.	Bonding rubber to rubber, metal or wood. Cyclizing necessary for optimum results.
R-86020	Special synthetic resin; single component system.	High tensile strength; excellent resistance to most chemical acids and alkalies. Heat resistant to 400°F; unlimited pot life.	For bonding metal to metal, ceramic to metal, metal to plastics.
R-86044	Special synthetic resin base; 2-component system.	Room temp. curing; 40 min. working life.	For bonding etched Teflon to metal, glass to glass, where optimum chemical resistance is desired.
R-87001	Synthetic rubber base.	Good adhesion; high peel strength up to 270°F; contains no flammable solvents.	For bonding fabrics to fabrics.

RAYBESTOS-MANHATTAN manufactures these 7 classes of adhesives, coatings and sealers:

1. Heat setting, synthetic resin adhesives, coatings, and sealers (not epoxy)
2. Cold setting, synthetic resin adhesives (not epoxy)
3. Heat setting, synthetic resin, synthetic rubber adhesives
4. Cold setting, synthetic resin, synthetic rubber adhesives
5. Rubber base adhesives
6. Synthetic resin sealants, and coatings (not epoxy)
7. Epoxy base adhesives, coatings and sealers; casting, encapsulating and potting compounds

Experienced Raybestos-Manhattan technicians will give you the benefits of more than 20 years of experience in the production of bonded assemblies and the manufacture of adhesives, coatings and sealers. They will provide you with full technical information and recommendations on the latest methods proved most efficient in many successful applications. Why not call on Raybestos-Manhattan engineers today to cut costs or improve production in your operations.

R/M Bulletin No. 701 contains helpful engineering information on Ray-Bond adhesives, protective coatings and sealers. Write for your free copy.

RAYBESTOS-MANHATTAN, INC.

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CUT TOTAL BRAZING COSTS *BY AS MUCH AS 75%* WITH SILVALOY PREFORMS

CHECK THESE ADVANTAGES OF SILVALOY PREFORMS.

1. Accurate control of quantity of alloy used on a job.
2. Enables operator to maintain uniform quality in brazing operation.
3. Allows alloy to be placed internally to flow outward to joint boundaries—aids in obtaining positive filling of the joint and a quick visual inspection for quality.
4. Simplifies feeding of alloy all around a diameter.
5. Internal placement of Silvaloy in large joints where flow distances are excessive.
6. Permits mechanization of brazing operation through furnace, induction, dip, resistance, gas burner or other suitable heating methods.
7. Silvaloy rings, segments, wire shapes, slugs, washers, discs, powders and plymetals are available *to your exact specifications!*

A Silvaloy technical expert will be glad to assist in planning for preforms. He can help you to save as much as 40% in labor costs—as much as 35% in brazing materials—speed production and improve brazing results in your plant. Call or write the Silvaloy distributor in your area.

SEND FOR "A COMPLETE GUIDE TO SUCCESSFUL SILVER BRAZING"

ENGELHARD
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SALES OFFICES: SAN FRANCISCO • LOS ANGELES • CHICAGO • NEW YORK • PROVIDENCE • MIAMI • ORLANDO • DALLAS

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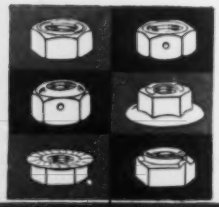
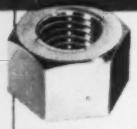
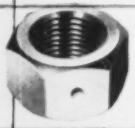
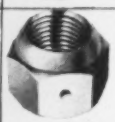
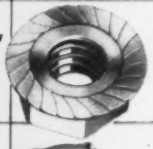
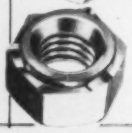
One  *of these*

CAN IMPROVE YOUR PRODUCT...

SIX GREAT

MACLEAN-FOGG LOCK NUTS

MF **UNI-TORQUE**		A free starter with lock at the top. Withstands severe vibrations. Cuts assembly time.
MF **TWO-WAY**		The Lock's in the center of nut. Can be applied from either end. Permits bolt end to be flush with, or below, top of nut.
MF OPEN END **CAP NUT**		Has two-way center-of-nut lock. Used on furniture, appliances, toys, lawn mowers, tools, etc.
MF UNI-TORQUE **FLANGE NUT**		Combination lock nut and washer. Use on oversized holes; where extra bearing surface is needed.
MF **"WHIZ-LOCK"** FLANGE NUT		This one spins on. Serrations take a firm grip on work. Break loose torque higher than seated torque.
MF PILOT TYPE **WELD NUT**		You can have it with or without lock. Simplifies assemblies by means of self-locating pilot.

CIRCLE NUMBER FOR ILLUSTRATED CATALOG

MAC LEAN-FOGG **LOCK NUTS**

MacLean-Fogg Lock Nut Company
5535 N. WOLCOTT AVENUE
CHICAGO 40, ILLINOIS

1925 **35** 1960
ANNIVERSARY

For more information, turn to Reader Service card, circle No. 441

No. 16 of a series

Eastman 910 Adhesive solves another production bottleneck

The A. W. Haydon Company, Waterbury, Connecticut, makes a newly-designed timing device for automatic telephone switchboards.

The nylon timer gears and associated cams had to be molded separately due to their complex shape, then joined on an assembly-line.

Fast-setting, high-strength Eastman 910 Adhesive proved to be the economical, easy-to-use means of bonding these nylon parts.

In assembly, the gear and cam are held in a simple jig and a drop of adhesive is applied. The mating surfaces are brought together and held for a few moments. *Within 10 seconds a strong bond is formed, and the part is assembled into the timer.*

Eastman 910 Adhesive is making possible faster, more economical assembly-line operations and new design approaches for many products. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

Eastman 910 Adhesive is used as it comes. No mixing, no heating. Simply spread the adhesive into a thin film between two surfaces. Light manual pressure triggers setting. With most materials, strong bonds are made within minutes.

What production or design problem can this unique adhesive solve for you?

Bonds Almost Instantly with Contact Pressure
No Heat...
No Catalyst...

For a trial quantity (⅓-oz.) send five dollars to Armstrong Cork Co., Industrial Adhesives Div., 9113 Dunbar Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Div., Dept. E-13, Kingsport, Tenn. (Not for drug use)
See Sweet's 1960 Prod. Des. File, 7/E

For more information, circle No. 401

HANDY ALLOY DATA SHEET

HANDY & HARMAN ENGINEERING DEPARTMENT
82 FULTON STREET, NEW YORK 38, N. Y.

ALLOY LIST

Handy & Harman Silver Brazing Alloys

...The COMPLETE line that meets all specifications and production needs

Need to join any combinations of metals – ferrous and nonferrous? Investigate the vast number of products, assemblies and parts that are being joined better by silver brazing alloys. Handy & Harman, the Number One Source of, and Authority On Brazing Alloys and Methods makes – and makes readily available – the following silver brazing alloys:

HANDY & HARMAN SILVER BRAZING ALLOYS

NAME	COMPOSITION PERCENTAGE				MELTING POINT		FLOW POINT		TROY OUNCES PER CU. IN.
	Ag	Cu	Zn	Other	°F	°C	°F	°C	
EASY-FLO	50	15½	16½	(18 Cd)	1160	625	1175	635	5.0
EASY-FLO 3	50	15½	15½	(16 Cd-3 Ni)	1170	630	1270	690	5.0
EASY-FLO 45	45	15	16	(24 Cd)	1125	605	1145	620	4.9
EASY-FLO 35	35	26	21	(18 Cd)	1125	605	1295	700	4.9
SIL-FOS	15	80		(5 P)	1185	640	1300	705	4.5
SIL-FOS 5	5	88¼		(6¼ P)	1185	640	1300	705	4.4
TEC*	5			(95 Cd)	640	340	740	395	4.6
TEC-Z*	5		16.6	(78.4 Cd)	480	250	600	315	4.5
BRAZE 071 (SN #7)†	7	85		(8 Sn)	1225	665	1805	985	4.8
" TL	9	53	38		1410	765	1565	850	4.5
" ATT	20	45	30	(5 Cd)	1140	615	1500	815	4.6
" 202 (AT SPEC)†	20	45	35		1315	715	1500	815	4.7
" NE	25	52½	22½		1250	675	1575	855	4.7
" 251 (AE)†	25	57½	17½		1270	690	1625	885	4.7
" NT	30	38	32		1250	675	1410	765	4.7
" DT	40	36	24		1235	670	1415	770	4.8
" SS	40	30	28	(2 Ni)	1220	660	1435	780	4.8
" 404 (SS-5)†	40	30	25	(5 Ni)	1220	660	1580	860	4.7
" DE	45	30	25		1225	665	1370	745	4.8
" ETX	50	34	16		1250	675	1425	775	5.0
" 541 (4772)†	54	40	5	(1 Ni)	1340	725	1575	855	5.1
" 560 (ER)†	56	22	17	(5 Sn)	1145	620	1205	650	5.0
" 580 (EB)†	57½	32½		(7 Sn-3 Mn)	1120	605	1345	730	5.1
" RT	60	25	15		1245	675	1325	720	5.0
" 603 (RT-SN)†	60	30		(10 Sn)	1115	600	1325	720	5.2
" 630 (RSNI)†	63	28½		(6 Sn-2½ Ni)	1275	690	1475	800	5.1
" EASY	65	20	15		1240	670	1325	720	5.1
" 655 (RE-MN)†	65	28		(5 Mn-2 Ni)	1385	750	1560	850	5.2
" MEDIUM	70	20	10		1275	690	1360	740	5.1
" BT	72	28			1435	780	1435	780	5.2
" HARD	75	22	3		1365	740	1450	790	5.3
" 752 (TR #1)†	75		25		1300	705	1330	720	5.1
" IT	80	16	4		1340	725	1490	810	5.3
" 852 (85 Ag-15 Mn)†	85			(15 Mn)	1760	960	1780	970	5.1
PREMABRAZE 610	61	24		(15 In)	1155	625	1305	705	5.0

*A Solder – Not a Brazing Alloy. †Former Names

Space does not permit listing the many special alloys, formulated for a particular or unique application. Handy & Harman Brazing Engineers and Technical Service are always ready to work closely with you on metal joining problems and methods.

Comprehensive technical literature covering all aspects of brazing methods and alloys awaits your request.

GET THE FACTS FROM BULLETIN 20

This informative booklet gives a good picture of silver brazing and its benefits...includes details on alloys, heating methods, joint design and production techniques. Write for your copy.

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PICK

the Bostik number that best answers your Design-Adhesive Needs

Bostik Adhesive	Principal use*	Characteristics*
258	Fabric to Rubber	Fast break — Quick grab
S28-72	General Purpose Latex Leather to Leather — Paper etc.	High tack — Quick grab
601	Polyethylene to itself Paper and Foil	Low adhesion — High tack
1007	Metal primer	Excellent adhesion to metals
1008 A&B	Primer for rigid plastics Neoprene to primed surfaces Neoprene to itself	High tack
1024 A&B	Neoprene to itself Neoprene to primed surfaces	Good heat resistance
1125 A&B	Neoprene to Neoprene	MIL-C-5540 Long-lasting band, long working period
1142	Neoprene inflatables General purpose Neoprene to itself and to Metal	MIL-A-1154B Excellent bonds
2003 A&B	Natural rubber to itself	MIL-C-5539 Long-lasting bond
2022	Paper to Paper	Excellent tack — Advertising layouts
2032 A&B	Leather to rubber	Excellent adhesion — good tack
2102	Pressure sensitive	High solids — High tack-knife coat
2293	Wallboard and hardboard to concrete and dry wall construction	One way, excellent bond
3035	General purpose	Permanent bond to many surfaces, including metals
4025	Butyral fabric to itself	Short tack, excellent adhesion
4034	Saran to itself and metals General purpose	MIL-C-4003 Good oil resistance
4040	Vinyl to vinyl and other materials.	Good aging, resistance to discoloration — Long tack
4500	Metal to Wood	One way heat activation
4585	General purpose	Good oil, water and detergent resistance
7008	Metal to Metals Metal to plastics Metal to Rigid paper	Reactivation by heat used extensively in electronics for speakers
7026	Metal to Metals Metal to plastics Ceramics to other materials	Used to bond rigid plastics to metal with heat and pressure
7028 A&B	Metal primer	Adheres various rubbers to metal without tie cements, heat and pressure required.
1178	Seam Sealant	Neoprene, black
1179	Seam Sealant	Neoprene, clear
7058	Seam Sealant	Vinyl affinity — Good light stability — clear in color
4777-81	Pressure sensitive coating	Clear in color. Good tack applied by roller coater

. . . then write for data sheets re: your choice and any others that look promising.

*types include natural, synthetic reclaim rubber and synthetic resin

Bostik®
ADHESIVES

BB CHEMICAL COMPANY • 784 MEMORIAL DRIVE • CAMBRIDGE 39, MASSACHUSETTS

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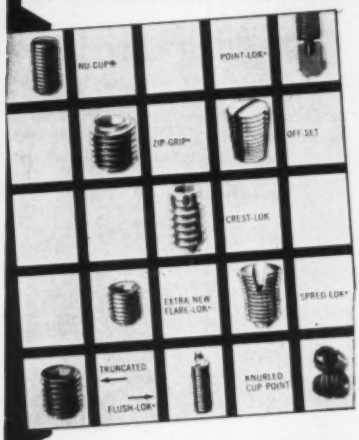
SETKO
self-locking set screws
WIN FOR YOU EVERY TIME!



ONE OF THESE NUMBERS COULD BE YOUR WINNING ANSWER TO:

- **Increased product reliability**
- **Lower costs**
- **More dependable performance**

Whatever your requirements demand — better holding power, resistance to vibration, ease of application, etc.—chances are you'll find the *right* answer among the many types of self-locking set screws made by Setko. Many of the styles illustrated here can be combined with various head styles, points or locking actions to give you a set screw that will fit your *specific needs best,* at the lowest cost.

Why not join the hundreds of companies who have been winning lower costs and better product performance with the exclusive holding characteristics of Setko self-locking set screws?

SEND FOR FREE SELECTOR CHART AND TEST SAMPLES!

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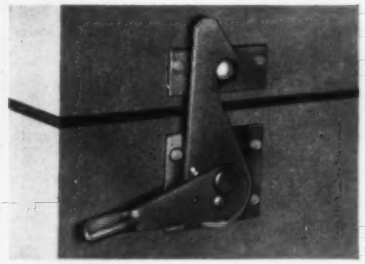
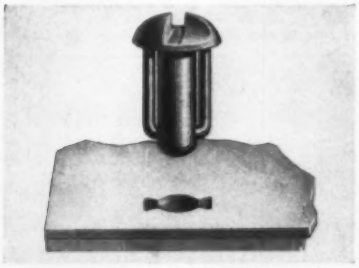
ANSWERS to specific fastening problems ...by SIMMONS

Economy, design flexibility, quick and easy installation, strength, and smooth, dependable action are advantages of these Simmons Fasteners, made for a variety of special applications. Whatever your fastening problem, engineering aid is available from Simmons.

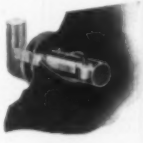


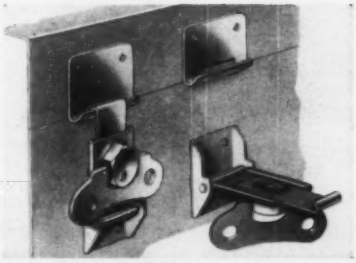
HOOK-LOCK–Springless, positive-locking latch which lies flat against mounting surface, open or closed. Provides high closing pressure and load-carrying capacity. For military as well as commercial container applications.



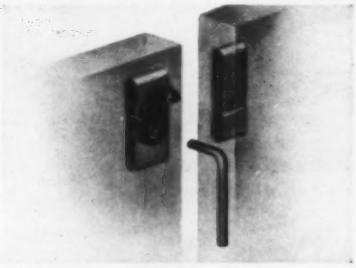
SPRING-LOCK–Perfect, proved blind rivet for removable covers and panels on electric and electronic equipment, sheet-metal automobile parts, appliances.

Plastic Spring-Lock Shelf Supports with "heart of steel" help refrigerator makers cut costs, speed production, simplify servicing.

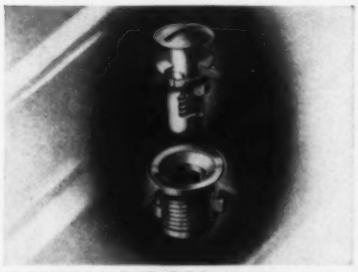




LINK-LOCK–Ideal latching device where heavy locking pressure is necessary. Available in heavy, medium, light duty, for use in military and commercial containers and demountable construction.

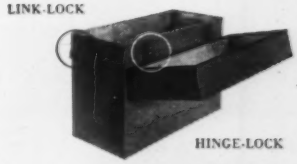


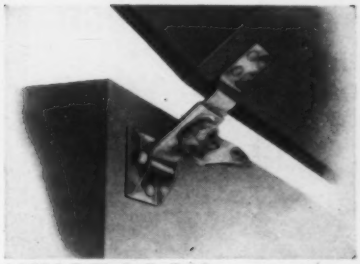
DUAL-LOCK–Impact and vibration-proof high-load butt-joint fastener that will not accidentally unlock or loosen. Recess in panels or surface mount. Withstands 7000-lb. tension.



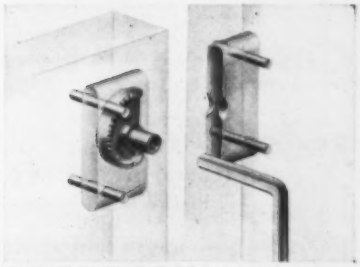
QUICK-LOCK–For assembling removable panels and access doors. Locked by a 90° turn. Various sizes and types, for weather-tight electrical units, cowlings, access panels.

SEND TODAY for your copy of the Simmons catalog, with specifications, applications, installation instructions for all Simmons Fasteners. Samples are available. For special assistance, describe your requirements.





HINGE-LOCK–A rugged pressure hinge which provides a strong seal along the hinge line of gasketed equipment containers and transit cases. Matched hardware with LINK-LOCK.



ROTO-LOCK–Versatile fastener for butt or right-angle joints in portable shelters, partitions, knock-down shipping boxes, etc. Solidly built, springless.

CLAMP-LOCK–A simple and strong, positive-locking clamp for fast assembly (and disassembly) of permanent or temporary rooms and buildings of flanged-panel construction.

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See our condensed catalog in Sweet's Product Design File

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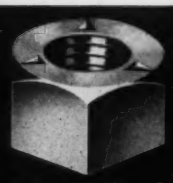

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One piece all metal

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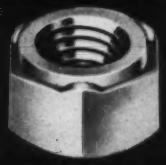
With or without self-locking threads. Hex collar prevents turning when torqueing bolt.



GRIPCO PILOT-PROJECTION WELD NUT
With or without self-locking threads. Centering collar positions nut and protects threads from weld spatter.

You get these "extras" when you specify GRIPCO®

FASTENERS—

Service—40 sales representatives all over the country for prompt, fast service.

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Locking feature in the center for fast feeding. Can be applied from either end.

GRIPCO COUNTERSUNK WELD NUT
With or without self-locking threads. Countersink protects threads from weld spatter.

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Stainless Processing Division

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HARD-SURFACING & BRAZING ALLOYS

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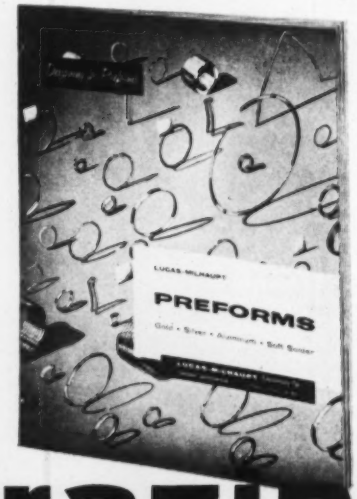

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- Round and Flat Wire Rings
- Curved Washers and Shims
- Types of Blanked and Edgewound Washers
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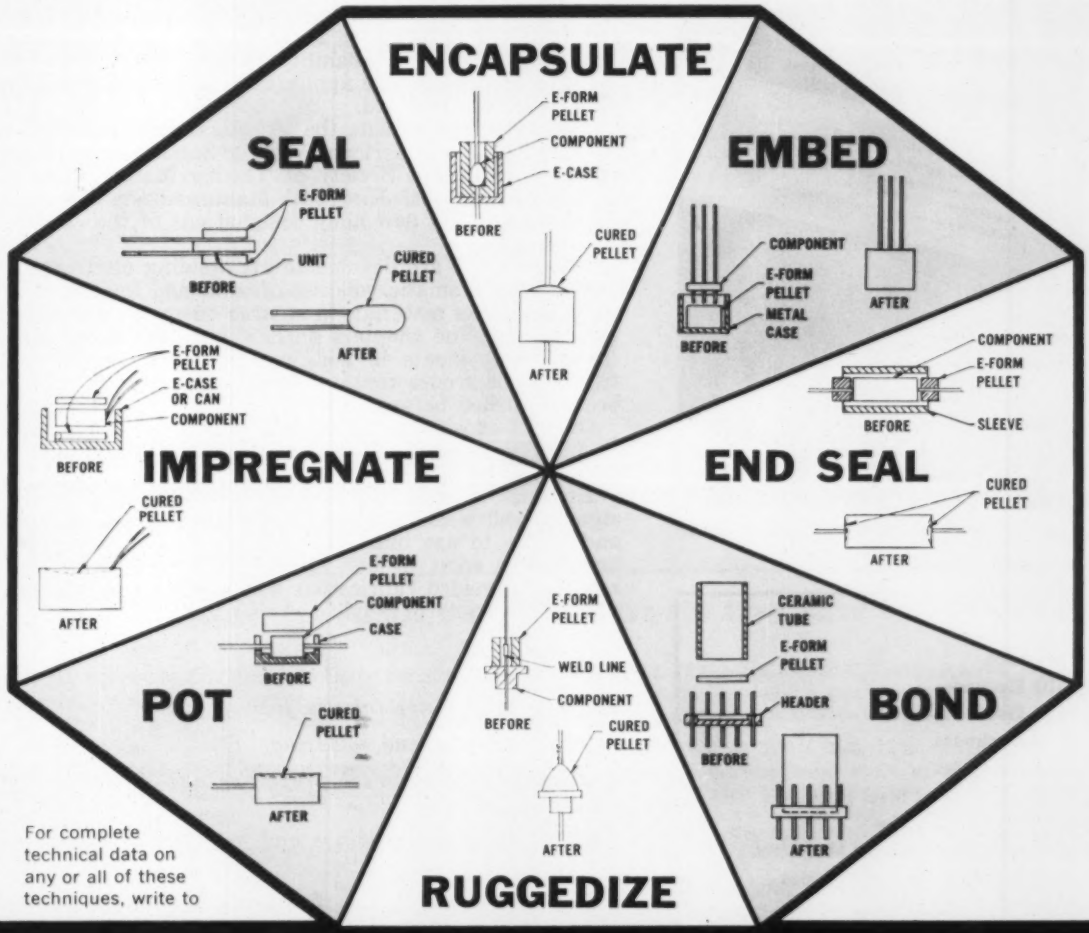
8 ways to use versatile E-FORM EPOXY PELLETS

Developed to overcome the measuring and handling drawbacks of liquid epoxy, E-FORM EPOXY PELLETS are non-toxic, dry, easy-to-handle units that can be provided in the exact size, shape, volume and formulation required for any insulating, adhesive, chemical resistant or flame-resistant application! Variations of cure temperature, color, flow and viscosity, heat dissipation, thermal expansion, physical and adhesive strength, flexibility, etc., are available to raise production efficiency, save time, cut rejects drastically and raise the standard of component performance.

Here are 8 ways to use versatile E-FORM EPOXY PELLETS in your plant now:



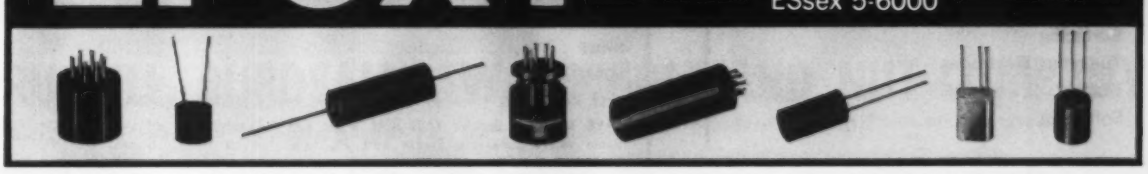
For complete technical data on any or all of these techniques, write to

EPOXY PRODUCTS

A DIVISION OF JOSEPH WALDMAN & SONS

137 Coit Street, Irvington, New Jersey

ESsex 5-6000



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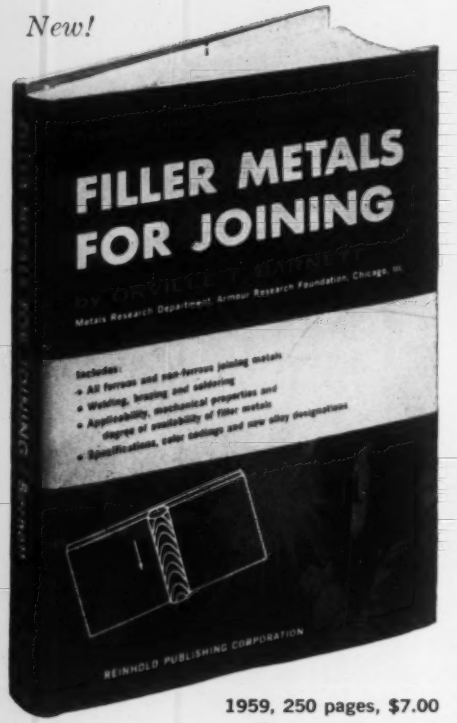
Presents all factors controlling the best choice . . .

FILLER METALS for JOINING

New!



1959, 250 pages, $7.00
Profusely illustrated

by **ORVILLE T. BARNETT,**
Metals Research Department,
Armour Research Foundation, Chicago, Illinois

This much-needed reference presents reasons for, and summarizes industrial practice in selecting the proper filler metal for any metal joining situation. It covers all of the ferrous and non-ferrous joining metals. Welding, brazing and soldering are treated with major emphasis on products for manual and automatic arc welding. Available materials are discussed in terms of applicability, mechanical properties and degree of availability. Where many filler metals are offered for a single application, factors controlling the best choice are outlined.

The book supplements the many excellent specifications prepared by the American Welding Society in cooperation with the American Society of Testing Materials, and includes the National Electrical Manufacturers Association color codings and new alloy designations of the Aluminum Association.

Ten chapters are devoted to arc welding electrodes, and another to automatic welding of mild and low alloy steels which discusses materials in an area where no specifications exist as yet. The chapters on new iron powder electrodes, latest developments in non-ferrous metals, surfacing and tungsten electrodes contain much material that has never been published before.

Over 84 experts in the field of joining reviewed portions of the text and made many pertinent and useful suggestions.

Here is a handy reference for welding engineers, designers, and welders who are interested in knowing when and where to use individual filler metals; for purchasing agents who want to look up competing products; and for anyone in welded fabrication who needs to choose among the great variety of products being marketed.

CONTENTS

Introduction
E6010 Electrodes
E6011 Electrodes
E6012 Electrodes
E6013 Electrodes
Low Hydrogen Mild Steel Electrodes
E6020-E6030 Electrodes
Iron Powder Electrodes for Mild Steel
Low-Alloy High-Strength Electrodes
Cast Iron
Stainless Steel
Automatic Welding, Mild and Low Alloy Steels
Aluminum and Aluminum Alloys
Copper and Copper Alloys
Nickel and Nickel Alloys
Surfacing
Tungsten Electrodes
Brazing
Soldering

INCLUDES—

All ferrous and non-ferrous joining metals

Welding, brazing and soldering

Applicability, mechanical properties and degree of availability

Specifications, color codings and new alloy designations

Examine It Free for 10 Days
MAIL THIS COUPON NOW!

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R B&W 116th year

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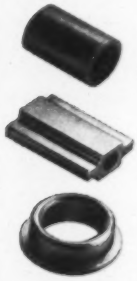
RB&W open-end acorn nuts of pigmented Delrin feature excellent strength, rigidity, dimensional stability, low cost, reusability, corrosion resistance. Constant prevailing torque. Metallic gray and other colors. Two sizes: No. 10 develops 500-600 lbs. clamping force; ¼-inch develops 600-700 lbs.

® Dupont Trade Mark

SPIN-LOCK SCREWS

These RB&W screws offer in flat head and filister head design a locking action similar to that of RB&W's Tensilock® screws. They have ratchet-like teeth that bite into the bearing surface when tightened and resist loosening from vibration or temperature cycling. Reusable. Wide range of sizes.

POWDERED METAL PARTS



A variety of small parts is presently being produced by RB&W from powdered brass and stainless steel. Facilities can handle a wide variety of other small shapes, including nuts, gears, bushings, spacers, levers, cams, etc. Such sintered parts offer substantial production savings. Contact us with your requirements.

STAKED LOCK NUTS

Staked on opposite sides for positive grip and spring tension locking effect. Available in regular double chamfered style or acorn style (illustrated), in aluminum, steel, silicon bronze.

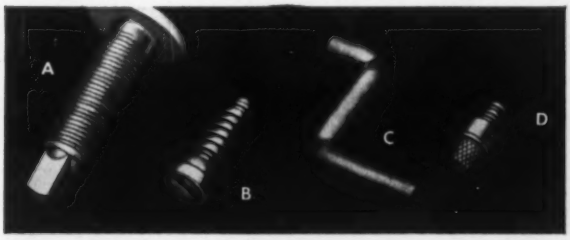
WELDING FASTENERS

RB&W standard welding screws have welding projections on top or bottom of head. Sizes from No. 6 through ½ inch. Welding Nuts can also be supplied.

Cold heading creates quality parts the low cost way

METAL FORCED to cold flow into shape results not only in savings but also in stronger parts. With uncut flow lines, the piece is better able to withstand stress concentrations.

No value analysis of product components is really complete without exploring what cold heading machines can do. Some examples:



ELIMINATE EXTRA OPERATIONS. Leveling screw (A), formerly made by riveting flat disc to set screw, now emerges as a stronger, single piece from a cold header.

ONE PIECE BETTER THAN TWO. Cold headed hose clamp screw (B) has integral flange which, after head is slotted, is forced up to form screwdriver shield. Before, piece was in two parts . . . with screw made on screw machine, and the shield a stamping fitted around head in extra assembly operation.

FASTER THAN FORGING. Shifter lever (C) is bent into double "L" automatically in bolt header . . . replacing 2-stage forging operation. The header does it at high speed from continuous rod.

METAL FLOWS TO SHAPE—NO WASTE. No longer cut on screw machine, insert screw (D) for plastic parts cost 40% less. Cold header uses just the amount of metal required. The threading and knurling, too, are done automatically at high speed.

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

RB&W fasteners—Strong Point of any assembly

See our catalog in Sweets Product Design File

Plants at: Port Chester, N.Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. **Additional sales offices at:** Ardmore (Phila.) Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

For more information, turn to Reader Service card, circle No. 543

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Directory Section

Suppliers of Materials

Addresses of Suppliers

THE DIRECTORY

This Directory is designed to be a comprehensive and up-to-date source of suppliers of engineering materials, forms, finishes and closely related services. The listings were compiled from information received from more than 3000 manufacturers, from official information made available by trade associations, and from many other sources.

HOW TO USE THE DIRECTORY

The Directory consists of two sections. In the first, the categories of materials, forms, finishes and related services are arranged alphabetically; suppliers in each category also are listed alphabetically with their geographical location indicated by state abbreviations. The many cross references make it easy to find any given category. In general, suppliers of basic or "mill" forms of materials, such as sheet, are listed under the particular materials, whereas suppliers of "fabricated" forms, such as forgings, are listed under the form.

Key letters in parenthesis following names of suppliers provide two kinds of additional information: 1) the basic materials in which a supplier furnishes a particular fabricated form, and 2) the basic forms in which a supplier furnishes a particular material (see key at right). For example, if you are looking for suppliers of magnesium sand castings, you will look for those suppliers of sand castings whose names are followed by the letter "e." Similarly, if you are looking for suppliers of cellulose acetate rod, you will look for those suppliers of cellulose acetate whose names are followed by the letters "bb."

Further information on a particular supplier's product can often be found by consulting an advertisement in this issue. Advertisers' names are bold-faced under the appropriate categories, and the pages on which their advertisements appear are listed following their names. Page numbers of advertisements are also given in the complete Index to Advertised Products, p 8, and the complete Index to Advertisers, pp 9-10.

The second part of the Directory contains a complete alphabetical list of suppliers and their addresses. To find the address of a division of a company, look up the name of the parent company (always given with the division name in the first part of the Directory).

In compiling a directory of this nature it is impossible to avoid errors and omissions. We will welcome corrections and suggestions. Please address them to Directory Editor, MATERIALS IN DESIGN ENGINEERING, *430 Park Ave., New York 22, N. Y.*

MATERIALS

- **a** Aluminum and its alloys
- **b** Copper and its alloys
- **c** Iron and its alloys (except steel)
- **d** Lead and its alloys
- **e** Magnesium and its alloys
- **f** Nickel and its alloys
- **g** Steels
- **h** Titanium and its alloys
- **j** Zinc and its alloys
- **k** Thermoplastics
- **l** Thermosetting plastics
- **m** Elastomers

BASIC FORMS

- **n** Anodes
- **o** Bar
- **p** Base resins, polymers or gums
- **q** Billets
- **r** Custom formed parts (incl. specialties)
- **s** Fibers
- **t** Film
- **u** Foams (component materials or products)
- **v** Foil
- **w** Ingot
- **x** Laminating, casting resins
- **y** Molding compounds
- **z** Plate
- **aa** Powder
- **bb** Rod
- **cc** Sheet
- **dd** Strip
- **ee** Tubing
- **ff** Wire

The listings and other data in this directory are compiled from sources believed reliable by the publisher. The publisher, however, does not represent or guarantee the accuracy of said listings and data, and no responsibility is assumed therefor.

Suppliers of Materials

ABS

(acrylonitrile-butadiene-styrene)

Bolta Products Div., General Tire & Rubber Co., Mass (cc)
Crane Plastics, Inc., Ohio (bb,dd,ee)
Colonial Plastics Mfg. Co., Div. of Van Dorn Iron Works Co., Ohio (bb,cc,dd)
Conneaut Rubber and Plastics Co., Div. of U. S. Stoneware Co., Ohio (bb, cc,dd,ee)
Denver Plastics Inc., Colo (bb,cc,dd,ee)
Goodrich, B. F. Chemical Co., Ohio (p,y)
Kaufman Glass Co., Del (bb,cc,dd, ee)
Lus-Trus Corp., Mich (dd,ee)
Madin Plastics Inc., NJ (y,cc)
Marbon Chemical Div., Borg-Warner Corp., Ind (y)—Ad pp 235-242
Naugatuck Chemical Div., U.S. Rubber Co., Conn (p,y)
Polymer Chemical Co., Ohio (x)
U.S. Rubber Co., Footwear Div., Ill (cc)
Western Plastics Corp., Wash (ee)
Western Textile Products Co., Mo (ee)

Acetal Plastics

Albany Novelty Mfg. Co., Mass (t,cc)
Anderson Assoc., Inc., Ohio (y)
Bamberger, Claude P., Inc., NJ (y)
Belding Corticelli Industries, NY (y)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Davis, Joseph Plastics Co., NJ (t,y, bb,cc,dd,ee)
du Pont de Nemours, E.I. & Co., Inc., Del (p,t,x,y)
Heyden Newport Chemical Corp., American Plastics Corp. Div., NY (bb,cc,dd,ee)
National Vulcanized Fibre Co., Del (bb,cc,ee)
Pennsylvania Fluorocarbon Co., Inc., Pa (ee)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (x)
Shawinigan Resins Corp., Mass (p)
Superior Plastics, Inc., Ill (bb,cc,ee)

Acetate

(see Cellulose Acetate)

Acrylate Rubber

(see Acrylic Rubber)

Acrylic Plastics

Ace Plastic Co., NY (bb,cc,dd,ee)
Adhesive Products Corp., NY (x)
American Molding Powder & Chemical Co., NY (y)
American Products Mfg. Co., Inc., La (t,bb,cc)
Anchor Plastics Co., Inc., NY (bb,dd, ee)
Anderson Assoc., Inc., Ohio (y)
Artus Corp., NJ (cc,dd)
Auburn Plastic Engineering, Ill (bb, cc,ee)
Auburn Plastics, Inc., NY (bb,dd,ee)
Bamberger, Claude P., Inc., NJ (y)
Blank, Arthur & Co., Inc., Mass (cc)
Borden Co., Borden Chemical Div., NY (p)
Cadillac Plastic & Chemical Co., Mich (p,x,bb,cc,dd,ee)
Cast Optics Corp., NJ (cc)
Catalin Corp. of America, NY (p)
Chemical Development Corp., Mass (p)
Colonial Kolonite Co., Ill (bb,cc,ee)
Colton Chemical Co., Div. of Air Reduction Co., Inc., Ohio (p)
Comco Plastics, Inc., NY (bb,cc,dd,ee)
Commercial Plastics & Supply Corp., NY (bb,cc,dd,ee)
Crane Plastics, Inc., Ohio (bb,dd,ee)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Curbell, Inc., NY (bb,cc,dd,ee)
Denver Plastics, Inc., Colo (bb,cc,dd, ee)
Dow Chemical Co., Plastics Div., Mich (s)
du Pont de Nemours, E.I. & Co., Inc., Del (p,s,x,y)
Dura Plastics of New York, Inc., NY (bb,cc,dd,ee)
Durable Formed Products, Inc., NY (cc,ee)
Dyna-Therm Chemical Corp., Calif (p)
Eljay Corp., Md (bb,cc,dd,ee)
Foss Mfg. Co., Id (cc)
Fry Plastics International, Calif (bb, cc)
Galigher Co., Utah (bb,cc,dd,ee)
General Aniline & Film Corp., NY (cc)
General Plastics Corp., Ind (cc)
General Plastics Mfg. Co., Wash (bb, cc,dd,ee)
Gering Plastics, Div. of Studebaker-Packard Corp., NJ (y)
Glass Laboratories, Inc., NJ (bb, dd, ee)
Grigoleit Co., Ill (p,s)
H & R Industries, Pa (bb,cc,dd,ee)
Hauger-Beegle Asso., Inc. Ill (t)
Heyden Newport Chemical Corp., American Plastics Corp. Div., NY (bb,cc,dd,ee)
Industrial Plastics Corp., Ind (bb,dd)
Jet Specialties Co., Inc., Calif (bb, dd,ee)
K S H Plastics, Inc., Mo (bb,cc,dd)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Luminous Resins, Inc., Ill (y)
Lus-Trus Corp., Mich (cc,ee)
Midwest Plastic Products Co., Ill (cc, dd)
Muehlstein, H. & Co., Inc., NY (p, y,cc)
Norrich Plastics Corp., NY (bb,cc,ee)
Perfex Plastics, Inc., Ill (bb,dd)
Philrus Products Co., NJ (bb,cc,dd, ee)
Plast-Ad Mfg. Co., Ind (bb,cc,dd,ee)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (x)
Plastic Compounding Corp., Sub. of Plastiglide Mfg. Corp., Calif (y)
Plastic Materials, Inc., NY (y)
Polycast Corp., Conn (cc)
Pyramid Industries, Inc., Pa (ee)
Radiation Applications, Inc., NY (bb, cc,dd,ee)
Reed Plastics Corp., Mass (y)
Rohm & Haas Co., Pa (y,cc)
Russell Mfg. Co., Conn (s)
Schwab Plastics Corp., Mich (bb,cc, dd,ee)
Scranton Plastic Laminating Corp., Pa (cc)
Snyder Mfg. Co., Inc., Ohio (cc)
Southern Plastics Co., SC (bb,cc,dd, ee)
Superior Plastics, Inc. Ill (bb,dd)
Union Carbide Corp., Union Carbide Chemical Co. Div., Textile Fibers Dept., NY (s)
United Shoe Machinery Corp., Mass (p)
Western Felt Works, Ill (cc)
Westlake Plastics Co., Pa (t,y,bb,cc, dd,ee)
World Plastics, NY (bb,cc,dd,ee)

Acrylic Rubber

Adhesive Products Corp., NY (x)
Bond International, Inc., Mich (y,ee)
Borden Co., Borden Chemical Div., NY (p)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chicago-Allis Mfg. Corp., Ill (p)
Continental Rubber Works, Pa (bb, cc,dd,ee)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
Dyna-Therm Chemical Corp., Calif (p)
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass (y,cc,ee)
Flexible Tubing Corp., Conn (ee)
Garlock Packing Co., NY (y,cc)
General Plastics Mfg. Co., Wash (bb, cc,dd,ee)
Goodrich, B.F. Chemical Co., Ohio (p,cc)
Maloney, F.H. Co., Tex (y)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
Norrich Plastics Corp., NY (bb,cc,dd, ee)
Parker Seal Co., Div. of Parker-Hannifin Corp., Calif (u)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (x)
Polymer Chemical Co., Ohio (x)
Roth Rubber Co., Ill (cc)
Russell Mfg. Co., Conn (s)
Southern Plastics Co., SC (bb,cc,dd,ee)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (p,y,cc)
Wasco Products, Inc., Mass (cc)
Western Felt Works, Ill (y,cc,dd,ee)
Williams-Bowman Rubber Co., Ill (y,bb,cc,dd,ee)

Acrylonitrile-Butadiene Rubber

Adhesive Products Corp., NY (x)
American Hard Rubber Co., Div. of Amerace Corp., NY (bb,cc,dd)
American Rubber Products Corp., Ind (u,bb,cc,dd,ee)
Anderson Assoc., Inc., Ohio (y)
Automotive Rubber Co., Inc., Mich (cc,dd)
Belko Corp., Md (y)
Bond International, Inc., Mich (y,ee)
Borden Co., Borden Chemical Div., NY (p)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chicago-Allis Mfg. Corp., Ill (p)
Continental Rubber Works, Pa (bb,cc, dd,ee)
Dayton Rubber Co., Ohio (y,bb,cc,dd, ee)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
Faultless Rubber Co., Ohio (y,bb,ee)
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass (y,cc,ee)
Firestone Tire & Rubber Co., Ohio (p)
Flexible Tubing Corp., Conn (ee)
Garlock Packing Co., NY (y,bb,cc,dd, ee)
Geauga Industries Co., Ohio (y,bb,dd)
Goodrich, B.F. Chemical Co., Ohio (p, cc)
Goodyear Tire & Rubber Co., Chemical Div., Ohio (p)
Goshen Rubber Co., Inc., Ind (y)—Ad p 438
Hewitt-Robins, Inc., Conn (cc,ee)
Home Rubber Co., NJ (y,bb,cc,dd,ee)
Lee Rubber & Tire Corp., Republic Rubber Div., Ohio (p,y,cc,dd,ee)
Luzerne Rubber Co., NJ (bb,cc,dd,ee)
Maloney, F.H. Co., Tex (y)
Marbon Chemical Div., Borg-Warner Corp., Ind (p,x,y)
Martin Rubber Co., Inc., NJ (y,dd,ee)
Mid-States Rubber Products, Inc., Ind (y)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (p,y)—Ad p 247
Paeco Rubber Co., Inc., Ohio (y,dd,ee)
Parker Seal Co., Div. of Parker-Hannifin Corp., Calif (u)
Parker, Stearns & Co., Inc., NY (y, bb,cc,dd,ee)
Polymer Chemical Co., Ohio (x)
Prince Rubber & Plastic Co., Inc., NY (bb,cc,ee)
Raybestos-Manhattan, Inc., Plastic Products Div., Pa (x)
Roberts Toledo Rubber Co., Ohio (ee)
Roth Rubber Co., Ill (y,cc)
Rubatex Div., Great American Industries, Inc., Va (u)
Saran Lined Pipe Co., Div. of Michigan Pipe Co., Mich (y,cc)
Sheller Mfg. Corp., Mich (u)
Southern Plastics Co., SC (bb,cc,dd, ee)
Stockwell Rubber Co., Inc., Pa (y,bb, cc,dd)
Technical Specialties Co., NY (dd)
Toyad Corp., Pa (u)—Ad p 260
Trostel, Albert Packings, Ltd.,Wis (y)
U.S. Rubber Co., NY (p)

Vulcan Rubber Products Div., Reeves Bros., Inc., NY (p,y,cc)
Vulcanized Rubber & Plastics Co., Pa (y)
Westlake Plastics Co., Pa (bb,cc,dd)
Western Felt Works, Ill (y,cc,dd,ee)
Williams-Bowman Rubber Co., Ill (y,bb,cc,dd,ee)

Adhesives

(see also Tapes)

Adhesive Products Corp., NY (k,l,m)
Alcylite Plastics & Chemical Corp., Calif (k,l)
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY (l)
American Cyanamid Co., Plastics & Resins Div., NY (l)
American Hard Rubber Co., Div. of Amerace Corp., NJ (k,l,m)
American Metaseal Corp., NJ (l)
American Products Mfg. Co., Inc., La (k,m)
American Sealants Co., Conn (l)
Angier Adhesives Div., Interchemical Corp., Mass (k,l,m)
Arabol Mfg. Co., NY (k)
Aries Laboratories, Inc., Conn (l)
Armour & Co., Adhesive Div., Ill (k, m)
Armstrong Cork Co., Pa (k,l,m)
Armstrong Products Co., Ind (l)
Atlantic Bag Co., NY (l)
Avery Label Co., Decorative Products Div., Ohio (l)
Avondale Co., Ill (k,l,m)
B. B. Chemical Co., Bostik Dept., Mass.
(k,l,m)—Ad p 496
Babbitt Chemical Co., Inc., Mass (k)
Beck, I. & Sons, Inc., NY (m)
Belding Corticelli Industries, NY (k,l, m)
Belko Corp., Md (m)
Biggs, Carl H. Co., Inc., Calif (k,l)
Bisonite Co., Inc., NY (l)
Borden Co., Borden Chemical Div., NY (k,l,m)
California Metal Enameling Co., Calif (k,m)
Campro Co., Ohio (k)
Capac Mfg. Corp., Mich (k,l,m)
Catalin Corp. of America, NY (l)
Ceilcote Co., Ohio (k,l,m)
Chemical Coatings & Engineering Co., Inc., Pa (k,l,m)
Chemical Development Corp., Mass (k,l)
Chemical Process Co., Calif (l)
Chemical Products Corp., RI (k,m)
Chrysler Corp., Cycleweld Div., Mich (k,l,m)
Ciba Co., Inc., NY (l)
Clinton Co., Ill (k,l,m)
Coast Pro-Seal & Mfg. Co., Calif (l,m)
Colonial Kolonite Co., Ill (k)
Connecticut Hard Rubber Co., Conn (m)
Continental Can Co., Conolite Div., Del (l)
Cooper, Peter Corp., NY (k)
Co-Polymer Chemicals Inc., Mich (l)
Cordo Chemical Corp., Conn (k,l,m)
CrystalX Corp., Pa (k)
Dacar Chemical Products Co., Pa (k, l,m)
Dayton Rubber Co., Ohio (k,l,m)
Dennis Chemical Co., Mo (k,m)
Devcon Corp., Mass (k,l)
Douglas & Sturgess, Calif (l,m)
Dow Corning Corp., Mich (m)
du Pont de Nemours, E.I. & Co., Inc., Del (k)
Durable Formed Products, Inc., NY (k)
Dyna-Therm Chemical Corp., Calif (k,l,m)
Eastman Chemical Products, Inc., Sub. of Eastman Kodak Co., NY
(k)—Ad p 494
Electro Chemical Engineering & Mfg. Co., Pa (k,l,m)
Electronic Production & Development, Inc., Chemical Div., Calif (l)
Emerson & Cuming, Inc., Mass (k,l,m)
Everlite Corp., Wash (k,l,m)
Fanner Mfg. Co., Munray Products Div., Ohio (k)
Fibercast Div., Youngstown Sheet & Tube Co., Okla (l)
Flexfirm Products, Calif (k)
Fluorocarbon Co., Calif (l)
Formica Corp., Sub. of American Cyanamid Co., Ohio (l)
Foss Mfg. Co., Id (l)
Franklin Glue Co., Ohio (k)
Fry Plastics International, Calif (k,l)
Fuller, H.B. Co., Minn (k,l,m)
Furane Plastics, Inc., Calif (l)
General Electric Co., Silicone Products Dept., NY (k,l)
General Mills, Inc., Chemical Div., Ill (k,l)
General Plastics Mfg. Co., Wash (k,l, m)
Gomar Mfg. Co., Inc., NJ (k)
Goodrich, B.F. Industrial Products Co., Ohio (k)
Goodyear Tire & Rubber Co., Chemical Div., Ohio (k)
Great Lakes Carbon Corp., NY (l)
Hadley Bros.-Uhl Co., Mo (m)
Hardman, H.V. Co., Inc., NJ (l)
Haskelite Mfg. Corp., Mich (k,l,m)
Haveg Industries, Inc., Del (l)
Hayes Adhesive Co., Inc., Mo (k,l)
Hiller Aircraft Corp., Adhesive Engineering Div., Calif (l)
Hughes Glue Co., Mich (k,l,m)
Hughson Chemical Co., Div. of Lord Mfg. Co., Pa (k,l,m)
Hysol Corp., NY (k,l,m)
Industrial Polychemical Service, Calif (k,l,m)
Interchemical Corp., NY (k,l,m)
Interchemical Corp., Finishes Div., NJ (k,l)
Jamestown Finishes, NY (k)
Johns-Manville Corp., NY (k,l,m)
Johns-Manville Corp., Dutch Brand Div., Ill (m)
Kendall Co., Polyken Sales Div., Ill (k,l)
Lee Rubber & Tire Corp., Pa (m)
Maas & Waldstein Co., NJ (k,l)
Magic Iron Cement Co., Ohio (k)
Magnesium Co. of America, Ind (k,l)
Maloney, F.H. Co., Tex (k,l,m)
Manhattan Adhesives Corp., NY (k,l, m)
Mansol Ceramics Co., NJ (l)
Marbiette Corp., NY (l)
Marbon Chemical Div., Borg-Warner Corp., Ind (k,l)
Mesa Plastics Co., Calif (l)
Midland Adhesive & Chemical Corp., Mich (k,l,m)
Minnesota Mining & Mfg. Co., Adhesives, Coatings & Sealers Div., Mich (k,l,m)
Miracle Adhesives Corp., NY (k,m)
Monsanto Chemical Co., Plastics Div., Mass (l)
Morningstar-Paisley Inc., NY (k)
Mystik Adhesive Products, Inc., Ill (k,l,m)
Narmco Industries, Inc., Narmco Materials Div., Calif (l,m)
National Casein Co., Ill (k,l)
National Starch & Chemical Corp., Structural Products Div., NY (k,l, m)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (k,l,m)
Nukem Products Corp., NY (k)
Ohio Adhesives Corp., Ohio (k,l,m)
Parker Paint Mfg. Corp., Ind (k)
Pawling Rubber Corp., NY (k,l)
Pecora, Inc., Pa (k,m)
Permacel, NJ (k,l,m)
Perry-Austen Mfg. Co., NY (l,m)
Peterson, D.J. Co., Wis (k)
Pierce & Stevens Chemical Corp., NY (k,l,m)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (k,l,m)
Plast-Ad Mfg. Co., Ind (k,l)
Poly Resins, Calif (l)
Polymer Chemical Co., Ohio (k,l,m)
Polymer Corp. of Pennsylvania, Sub. of Polymer Corp., Pa (k)
Polymer Industries, Inc., Conn (k,l,m)
Presstite Div., American-Marietta Co., Mo (k,lm)
Quelcor, Inc., Pa (l)
Radiation Applications, Inc., NY (k, l,m
Randolph Products Co., NJ (k,l,m)
Raybestos - Manhattan, Inc., Adhesives Div., Conn
(k,l,m)—Ad p 492
Reichhold Chemicals, Inc., NY (k,l)
Ren Plastics, Inc., Mich (l)
Reynolds Aluminum Supply Co., Ga (k,l)
Riverside Plastics Corp., NY (l)
Rohm & Haas Co., Pa (k,l)
Rubber & Asbestos Corp., NJ (k,l,m)
Rubber & Plastics Compound Co., Inc., NY (k)
St. Clair Rubber Co., Mich (m)
Sauereisen Cements Co., Pa (k,l)
Schwartz Chemical Co., Inc., NY (k, l,m)
Shell Chemical Co., NY (l)
Sillcocks Miller Co., NJ (k)
Snyder Mfg. Co., Inc., Ohio (k)
Southern Adhesives Corp., Va (k,l,m)
Standard Insulation Co., NJ (l)
Steelcote Mfg. Co., Mo (l)
Stockwell Rubber Co., Inc., Pa (m)
Superior Plastics, Inc., Ill (k)
Surprenant Mfg. Co., Mass (k)
Swedlow, Inc., Calif (l)
Swift & Co., Adhesives Dept., Ill (k,m)
Synco Resins, Inc., Conn (k,l)
Toyad Corp., Pa
(m)—Ad p 260
U B S Chemical Corp., Mass (k,l,m)
Union Paste Co., Mass (k,l)
United Shoe Machinery Corp., Mass (k,l,m)
U.S. Stoneware Co., Ohio (k,l)
Waldman, Joseph & Sons, Epoxy Products Div., NJ
(l)—Ad p 499
Waterman Industries, Inc., Calif (k,l)
Western Plastics Corp., Wash (k)
Westlake Plastics Co., Pa (k)
Williamson Adhesives, Inc., Ill (k,l,m)

Alkyd Plastics

Adhesive Products Corp., NY (x)
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY (p,y)
American Cyanamid Co., Plastics & Resins Div., NY (p)
Anderson Assoc., Inc., Ohio (y)
Archer-Daniels-Midland Co., Minn (p)
Booty Resineers Div., American-Marietta Co., Ohio (p)
Dyna-Therm Chemical Corp., Calif (p)
Electrofilm, Inc., Calif (t)
Fiber Glass Industries, Inc., NY (u,x, y,cc)
Foss Mfg. Co., Id (cc)
General Electric Co., Insulating Materials Dept., NY (p)
Glaskyd, Inc., Ohio (y)
Hays Mfg. Co., Pa (y)
Hercules Powder Co., Inc., Del (p)
Jones-Dabney Co., Div. of Devoe & Raynolds Co., Inc., Ky (p)
Kurz Kasch, Inc., Ohio (y)
Naugatuck Chemical Div., U.S. Rubber Co., (p,x,y)
Panelyte Div., St. Regis Paper Co., NJ (x,y)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (x)
Reichhold Chemicals, Inc., NY (p)
Schenectady Varnish Co., Inc., NY (p)
Sherwin-Williams Co., Ohio (p)
Specialty Resins Co., Calif (p)
Westinghouse Electric Corp., Micarta Div., SC (p)

Alloy Steels

(see Steel)

Aluminides

(see Refractories)

Aluminized Metals

(see Precoated Metals)

Aluminizing

(see Immersion Coatings)

Aluminum and Its Alloys

Acme Tube, Inc., NJ (ee)
Adams Engineering Co., Inc., Fla (q, ee)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Advance Screw Products Co., Inc., Wis (o)
Advance Stamping Co., Mich (dd)
Aerolite Extrusion Co., Ohio (n,o,bb, dd,ee)
Alabama Wire Co., Inc., Ala (ff)
Albert Pipe Supply Co., Inc., NY (ee)
Alcasco Foundry, Ill (w)
Alloys & Chemicals Mfg. Co., Inc., Ohio (w,aa)
All-State Welding Alloys Co., Inc., NY (ff)
Alofs Mfg. Co., Mich (cc,dd,ff)
Alpha Metals, Inc., NJ (v)
Aluminium Ltd. Sales, Inc., NY (q,w)
Aluminum Co. of America, Pa (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Aluminum Billets, Inc., Ohio (q)
Aluminum Foils Co., Tenn (v)
American Brass Co., Sub. of Anaconda Co., NY (cc,dd,ee)
American Nickel Alloy Mfg. Corp., NY (w,aa)
American Silver Co., NY (v,dd,ee,ff)
American Smelting & Refining Co., NY (w)
Anaconda Aluminum Co., Sub. of Anaconda Co., Ky (o,q,v,w,z,bb,cc,dd,ee)
Apex Smelting Co., Ill (o,q,w,bb)
Arcos Corp., Pa (ff)
Armet Alloys, Inc., Ohio (w)
Arrow Metal Products Corp., NJ (cc)
Atlantic Powdered Metals, Inc., NY (aa)
Atlantic Steel Co., Ga (o,cc)
Auld, D.L. Co., Ohio (o,bb,cc,dd,ff)
Aurora Refining Co., Ill (w)
Babson Dow Mfg. Co., Mass (o)
Badger Aluminum Extrusions, NY (o, q,dd,ee)
Baer Bros. Bronze Powder Co., Inc., Mass (aa)
Bay State Refining Co., Inc., Mass (w)
Belmont Smelting & Refining Works, Inc., NY (n,w,aa)
Biddle Screw Products Co., Ind (o, bb,ee)
Bohn Aluminum & Brass Corp., Mich (o,q,bb,ee)
Bonnell, William L. Co., Inc., Ga (bb,ee)
Both, O.A. Corp., Mass (aa)
Bridgeport Brass Co., Conn (o,bb,cc, dd,ee)
Bridgeport Rolling Mills Co., Conn (dd)
Briel Industries, Inc., Ind (q,w)
Brinkerhoff Brass & Bronze Works, Inc., NY (z,bb,cc,dd,ee)
Bunting Brass & Bronze Co., Ohio (o)
Caspers Tin Plate Co., Ill (cc,dd)
Castle, A.M. & Co., Ill (o,z,bb,cc,dd, ee,ff)
Central Fabricators, Inc., Ohio (z,bb, cc,ee)
Channel Master Corp., NY (q,ee)
Clad-Rex Corp., Ill (cc)
Clark Perforating Co., Mich (cc,dd)
Clarksville Foundry & Machine Works, Tenn (o,w,z,ee)
Cleveland Electro Metals Co., Ohio (w)
Commercialores, Inc., SC (aa)
Copper & Brass Sales, Inc., Mich (o, z,bb,dd,ee,ff)
Corson Industries, Pa (q,bb,ee)
Craft Metal Spinning Co., Ill (cc)
Crane Co., Metals Div., Pa (aa)
Crescent Bronze Powder Co., Ill (aa)
Designers Metal Corp., Ill (cc)
Dixie Aluminum Corp., Ga (o,q,bb,ee)
Dormont Mfg. Co., Pa (ee)
Dow Metal Products Co., Div. of Dow Chemical Co., Mich (z,cc,ee,ff)
Dudek & Bock Spring Mfg. Co., Ill (ff)
Eastern Rolling Mills, Inc., NY (cc,dd)
Edgcomb Steel & Aluminum Corp., NJ (o,z,cc,dd,ee)
Empire Metal Co., NY (o,q,w)
Essex Industrial Products Div., Essex Wire Corp., Ind (ff)
Essex Wire Corp., Magnet Wire Div., Ind (ff)
Eynon-Dakin Co., Mich (ee)
Fairmont Aluminum Co., W. Va
(cc,dd)—Ad p 161
Federated Metals Div., American Smelting and Refining Co., NY
(o,w)—Ad p 173
Flynn, Michael Mfg. Co., Pa (o,bb,ee)
Foamalum Corp., Ill (foamed)
Foil Div., Reynolds Metals Co., Va (v)
Frasse, Peter A. & Co., Inc., NY
(o,z,bb,cc,dd,ee,ff)—Ad p 179
Fromson Orban Co., Inc., NY (o,z, bb,cc,dd,ee,ff)
Frontier Bronze Corp., NY
(w)—Ad p 178
General Cable Corp., NY (ff)
General Extrusions, Inc., Ohio (o,bb, ee)
General Smelting Co., Pa (w)
Gold Leaf & Metallic Powders, Inc., NY (aa)
Harbot Die Casting Corp., NJ (w)
Hardy, Charles, Inc., NY (aa)
Harris, Benjamin & Co., Ill (w)
Harvey Aluminum, Calif (o,q,w,bb,ee)
Hayden Wire Works, Inc., Mass (aa)
Haydon Corp., NY (ee)
Hexcel Products, Inc., Calif (v)
Himmel Bros. Co., Conn (o)
Hommel, O. Co., Pa (aa)
Horton-Angell Co., Mass (ee,ff)
Houston Blow Pipe & Sheet Metal Works, Tex (o,z,cc)
Hunter Engineering Co., Calif (o,bb, cc,dd,ee)
Industrial Foil Div., Aluminum Co. of America, Pa (foil)
Inshield Die & Stamping Co., Ohio (cc,dd)
Jackson Steel Products, Inc., NY (ee)
Jarl Extrusions, Inc., NY (o,q,bb,ee)
Jelliff, C.O. Mfg. Corp., Conn (ff)
Jobbins, William F., Inc., Ill (w)
Johnston Foil Div., Standard Packaging Corp., Mo (v,cc)
Kaiser Aluminum & Chemical Sales, Inc., Ill (n,o,q,v,w,z,bb,cc,dd,ee,ff)
Kawecki Chemical Co., NY (w)
Kawneer Co., Mich (o,q,z)
Kinkead Industries, Inc., Ill (q,z,cc, dd)
Kirk, Morris P. & Son, Calif (w)
Korhumel Steel & Aluminum Co., Ill (o,z,bb,cc,dd,ee,ff)
Laminated Shim Co., Conn (cc)
Langsenkamp, F.H. Co., Ind (o,z,bb, cc,dd,ee,ff)
Light Metals, Inc., Ind (n)
Lockhart Iron & Steel Co., Pa (o, z,bb,cc,dd,ee)
Lucas-Milhaupt Engineering Co., Wis (dd,ff)
Lundquist Tool & Mfg. Co., Inc., Mass (cc,dd)
Magna Mfg. Co., Inc., NJ (aa)
Magnode Products, Inc., Ohio (o)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass. (o,ee)
Malone Bronze Powder Works, Inc., NY (aa)
May, Inc., Tex (o,bb,ee)
McGregor-Michigan Corp., Mich (ee)
Metal Goods Corp., Mo (o,z,bb,cc,dd, ee,ff)
Metallizing Co. of Los Angeles, Inc., Calif (bb,ff)
Metallizing Engineering Co., Inc., NY (ff)
Metals Disintegrating Co., Inc., NJ (aa)
Morrisville Foundry Co., Inc., Vt (bb)
Mueller Brass Co., Mich (bb)
Murray, A.B. Co., Inc., NJ (ee)
National Aluminum Co., Ohio (bb,ee)
National Lead Co., NY (o,bb,ee)
National U.S. Radiator Corp., Plastic Metals Div., NY (aa)
Navan Products, Inc., Sub. of North American Aviation, Inc., Calif (w)
Nesor Alloy Products Co., NJ (ff)
New Jersey Aluminum Extrusion Co., Inc., NJ (bb,ee)
New Jersey Metals Co., NJ (w)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (w)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb,ee)
Nuclear Metals, Inc., Mass (bb,dd,ee)
Olds Alloys Co., Calif (ee)
Olin Mathieson Chemical Corp., Metals Div., NY (o,q,w,z,bb,cc,dd,ee,ff)
Ormond Mfg. Co., Inc., NJ (dd,ff)
Penn Extrusion Corp., Pa (ee)
Pioneer Aluminum, Inc., Calif (o,z,bb, cc,ee)
Pfister Tubing Corp., NJ (ee)
Precision Tube Co., Inc., Pa (ee)
Purdy, A. R. Co. Inc., NJ (o,z,bb,cc, dd,ee,ff)
Quaker State Metals Co., Pa (cc)
Rathbone Corp., Mass (bb)
Reade Mfg. Co., Inc., NJ (aa)
Republic Foil, Inc., Conn (v)
Republic Metals Co., Inc., NY (o,v, w)
Revere Copper & Brass, Inc., NY (o,q, v,w,z,bb,cc,dd,ee)
Reynolds Aluminum Supply Co., Ga (o, z,bb,cc,dd,ee,ff)
Reynolds Metals Co., Va (o,q,v,w,z,aa, bb,cc,dd,ee,ff)
Rigidized Metals Corp., NY (cc,dd)
Rodney Metals, Inc., Mass (v,dd)
Roebling's, John A. Sons Div., Colorado Fuel & Iron Corp., NJ (dd,ff)
Ryerson, Joseph T. & Son, Inc., Ill (o,q,z,bb,cc,dd,ee,ff)
Saginaw Bearing Co., Mich (o)
Sail, George Metals Co., Inc., Pa (w)
Scovill Mfg. Co., Mill Products Div., Conn
(bb,cc,dd)—Ad pp 169-170
Security Sash & Screen Co., Mich (cc)
Sel-Rex Corp., NJ
(n)—Ad p 356
Sherwatt Equipment & Mfg. Co., Inc., NY (ff)
Smith-Moon Steel Co., Inc., Kan (o,z,cc)
Sonken-Galamba Corp., Kan (q,w)
Southern Aluminum Finishing Co., Inc., Ga (o,z,bb,cc,dd,ee)
Standard Metals Corp., Mass (ee)
Star Heel Plate Co., Inc., NJ (ff)
Stranahan Foil Co., Inc., NJ (v)
Sun Steel Co., Ill (cc,dd)
Techalloy Co., Inc., Pa (n,dd)
Texas Instruments, Inc., Metals & Controls Div., Mass (v)
Trim Alloys, Inc., Mass (o,bb,ee)
Ullmann, Inc., Wis (o,ee)
United Screw & Bolt Corp., Ill (bb, cc,dd,ff)
United Smelting & Aluminum Co., Inc., Conn (cc,dd)
U.S. Bronze Powder Works, Inc., NJ (aa)
U.S. Extrusions Corp., NY (bb)
U.S. Gasket & Shim Co., Ohio (v)
U.S. Reduction Co., Ind (w)
United Wire & Supply Corp., RI (ee, ff)
Universal Converting Corp., Mass (o, bb,ee)
Utility Mfg. Co., Mass (bb)
Vanadium Corp. of America, NY (w)
Vulcan Rail & Construction Co., NY (o,z,ee)
Wallace Tube Co., Div. of Wallace Supplies Mfg. Co., Ill (ee)
Warner Mfg. Corp., NJ (o,bb,ee)
Waterman Industries, Inc., Calif (o,bb, cc,dd,ee)
Wells Aluminum Corp., Ind (o,bb,ee)
Werner, R.D. Co., Pa (o,q,w,bb,ee)
White Metal Rolling & Stamping Corp., NY (o,q,bb,ee,ff)
Whitehead Metal Products Co., Inc., NY (o,w,z,bb,cc,dd,ee,ff)
Wilder Mfg. Co., Inc., Calif (o,cc)
Wilson-Hurd Mfg. Co., Inc., Wis (cc)
Wright, Albert Screw Machine Products, Calif (bb)

Aluminum Bronze
(see Copper)

Anodes
(see specific metal)

Anodic Coatings
(see Conversion Coatings)

Asbestos
Aerojet-General Corp., Structural Materials Div., Calif (r)
American Asbestos Textile Corp., Pa (r,s)
American Brakeblok Div., American Brake Shoe Co., Mich (r)
American Smelting & Refining Co., NY (s)
Asbestos Corp. of America, NJ (r,s)
Asbestos Textile Co., Inc., Ill (r,s,cc)
California Metal Enameling Co., Calif (r)
Carey, Philip Mfg. Co., Ohio (r,s,cc)
Carolina Asbestos Co., NC (r)
Chicago Gasket Co., Ill (cc)
Connell Asbestos Mfg. Co., NY (r)
Dumont Corp., Calif (r,z,bb,cc,ee)
Firestone Tire & Rubber Co., World Bestos Div., Ind (r,cc)
Garlock Packing Co., NY (r,s,cc,ee)
Gatke Corp., Ill (r)
General Asbestos Gasket Mfg. Corp., Mo (r)
General Gasket, Inc., Conn (r)
Hall, C. P. Co., Ohio (s)
Insulation Mfrs. Corp., Ill (ee)
Johns-Manville Corp., NY (r,s,aa,cc,ee)
Keasbey & Mattison Co., Pa (s,cc,ee)
Lake Asbestos of Quebec, Ltd., Sub of American Smelting & Refining Co., NY
(r,s,cc)—Ad pp 316-317
Mica Fabricating Co., NJ (s)
National Gasket & Washer Mfg. Co., Inc., NY (r,cc)
Nicolet Industries, Inc., NY (r,s,cc,ee)
North American Asbestos Corp., Ill (r,s)
Panelyte Div., St. Regis Paper Co., NJ (bb,cc)
Peerless Products Industries, Ill (r)
Philadelphia Asbestos Corp., Pa (r)
Precision Paper Tube Co., Ill (ee)
Prince Rubber & Plastics Co., Inc., NY (cc,dd)
Raybestos-Manhattan, Inc., NJ (bb,cc)
Raybestos-Manhattan, Inc., Raybestos Div., Conn (r)
Riegel Paper Corp., NY (r)
Rogers Corp., Conn (cc)
Rostone Corp., Ind (r)
Ruberoid Co., NY (s)
Russell Mfg. Co., Conn (r,s)
Smith Chemical & Color Co., Inc., NY (aa)
Southern Asbestos Co., NC (r,s,ee)
Standard Asbestos Mfg. Co., Ill (r,s)
Staver Co., Inc., NY (r,cc)
Stone Paper Tube Div., Stone Straw Corp., Washington, DC (ee)
Superior Mfg. Co., Pa (r)
Union Asbestos & Rubber Co., Ill (r, cc,ee)
U.S. Polymeric Chemicals, Inc., Conn (s)
U.S. Rubber Co., NY (s)
U.S. Stoneware Co., Ohio (r)
Vellumoid Co., Mass (r,cc)
Victor Mfg. & Gasket Co., Ill (r,cc)

Balsa Wood
(see Wood)

Bar
(see specific metal)

Beryllium

Advance Stamping Co., Mich (dd)
American Silver Co., Inc., NY (v,dd)
Babson Dow Mfg. Co., Mass (o)
Belmont Smelting & Refining Works, Inc., NY (o,aa)
Beryllium Corp., Pa
(o,q,w,aa,bb)—Ad p 157
Bridgeport Brass Co., Conn (dd)
Brinkerhoff Brass & Bronze Works, Inc., NY (dd)
Brush Beryllium Co., Ohio
(o,q,v,w,z,aa,bb,cc,dd,ee)—Ad p 171
Craft Metal Spinning Co., Ill (cc)
Dudek & Bock Spring Mfg. Co., Ill (ff)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (ff)
Inshield Die & Stamping Co., Ohio (dd)
Instrument Specialties Co., Inc., NJ
(bb,dd,ff)—Ad p 463
Landquist Tool & Mfg. Co., Inc., Mass (cc,dd)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (dd,ff)
Mallory, P.R. & Co., Inc., Ind (bb, dd)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb)
Nuclear Metals, Inc., Mass (w,bb,cc, dd,ee,ff)
Olds Alloys Co., Calif (ee)
Riverside-Alloy Metal Div., H. K. Porter Co., Inc., NJ
(bb,ff)—Ad p 160
Rodney Metals, Inc., Mass (v,dd)
Sel-Rex Corp., NJ
(n)—Ad p 356
Seymour Mfg. Co., Conn (bb)
Stauffer-Temescal Co., Calif (o,q,w)
Superior Tube Co., Pa
(ee)—Ad pp 414-415
Texas Instruments, Inc., Metals & Controls Div., Mass (v)

Beryllium Copper

(see Copper)

Billets

(see specific metal)

Bismuth and Its Alloys

Alpha Metals, Inc., NJ (o,q,v,bb,cc,dd)
American Metal Climax, Inc., NY (o,w,aa)
Anaconda Co., NY (o)
Belmont Smelting & Refining Works Inc., NY (n,o,w,aa)
Cerro de Pasco Sales Corp., NY
(w)—Ad p 178
Division Lead Co., Ill (o,ff)
Empire Metal Co., NY (n,o,q,w,bb,ff)
Federated Metals Div., American Smelting & Refining Co., NY (o,w)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (aa)
Metals Disintegrating Co., Inc., NJ (aa)
Peerless Alloy Co., Colo (o,w)
Republic Metals Co., Inc., NY (o,w)
River Smelting & Refining Co., Ohio (o)
Sel-Rex Corp., NJ
(n)—Ad p 356
United Refining & Smelting Co., Ill (n,o,q,w,z,bb,cc,dd,ff)
U.S. Smelting, Refining & Mining Co., NY (w,dd)

Borides

(see Refractories)

Brass

(see Copper)

Brazing Alloys

Abalon Precision Mfg. Corp., NY
All-State Welding Alloys Co., Inc., NY
Alofs Mfg. Co., Mich
American Platinum & Silver Div., Engelhard Industries, Inc., NY
—Ad p 493
American Products Corp., Ill
American Silver Co., NY
Ampco Metal, Inc., Wis
Belmont Smelting & Refining Works, Inc., NY
Bridgeport Brass Co., Conn
Burgess-Norton Mfg. Co., Ill
Composite Industrial Metals, Inc., RI
Crucible Steel Co. of America, Pa
Dana Corp., Auburn Div., Ind
Dormont Mfg. Co., Pa
Electric Materials Co., Pa
Eutectic Welding Alloys Corp., NY
Falstrom Co., NJ
Farrelloy Co., Pa
General Findings & Supply Co., Industrial Div., Mass
Glidden Co., Ind
Glidden Co., Chemical Divs., Metals Dept., Ind
Goldsmith Bros. Div., National Lead Co., Ill
Handy & Harman, NY
—Ad p 495
Hayden Wire Works, Inc., Mass
Haynes Stellite Co., Div. of Union Carbide Corp., Ind
Inland Mfg. Co., Neb
International Nickel Co., Inc., NY
Jervis Corp., Mich
Kenmore Machine Products, Inc., NY
Kinkead Industries, Inc., Ill
Kling Metal Spinning & Stamping Co., NY
Kwikset Powdered Metal Products, Calif
Lincoln Iron Works, Vt
Lucas - Milhaupt Engineering Co., Wis
—Ad p 498
Machine Products Corp., Ohio
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass.
Mansol Ceramics Co., NJ
McDowell Mfg. Co. Pa
Revere Copper & Brass, Inc., NY
Rockwell Engineering Co., Ill
Sall, George Metals Co., Inc., Pa
Trenton Pipe Nipple Co., NJ
United Wire & Supply Corp., RI
Uniworld Research Corp. of America, Ohio
Vanadium-Alloys Steel Co., Pa
Victor Equipment Co., Calif
Wall Colmonoy Corp., Stainless Process Div., Mich
—Ad p 498
Waterman Industries, Inc., Calif
West Haven Foundry Co., Conn
Western Gold & Platinum Co., Sub. of Wilbur B. Driver Co., Calif
Whitehead Metal Products Co., Inc., NY

Bronze

(see Copper)

Buna N Rubber

(see Acrylonitrile-Butadiene Rubber)

Butadiene Styrene

(see Styrene Butadiene)

Butyl Rubber

(see Isoprene-Isobutylene Rubber)

Butyrate

(see Cellulose Acetate Butyrate)

Cadmium

Allied Research Products, Inc., Md (n)
Alpha Metals, Inc., NJ (o,q,v,bb,cc,dd)
American Metal Climax, Inc., NY (n,o,w,aa,bb)
American Silver Co., NY (v,dd)
American Smelting & Refining Co., NY (n,q,w)
American Zinc Sales Co., Mo (n,o,z)
Anaconda Co., NY (o)
Anchor Metal Co., Inc., NY (w)
Auld, D.L. Co., Ohio (n)
Belmont Smelting & Refining Works, Inc., NY (n,o,v,w,z,aa,cc)
Bunker Hill Co., Calif (n,o)
Cerro de Pasco Sales Corp., NY
(z,bb)—Ad p 178
Division Lead Co., Ill (v,cc)
Eagle-Picher Co., Ohio (q)
Empire Metal Co., NY (n,o,q,w,bb,ff)
Federated Metals Div., American Smelting & Refining Co., NY (n,o,w)
Goldsmith Bros. Div., National Lead Co., Ill (o,w)
Hamilton Watch Co., Precision Metals Div., Pa (v,cc,dd)
Hardy, Charles, Inc., NY (aa)
Harshaw Chemical Co., Ohio (n)
Hayden Wire Works, Inc., Mass (ff)
Hull, R.O. & Co., Inc., Ohio (n)
International Minerals and Metals Corp., NY (w)
Lucas-Milhaupt Engineering Co., Wis (dd,ff)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (dd,ee,ff)
McGean Chemical Co., Ohio (n,dd)
Metals Disintegrating Co., Inc., NJ (aa)
Modern Plating Corp., Ill (n)
New Jersey Metals Co., NJ (n)
New Jersey Zinc Co., NY (n)
Octagon Process, Inc., NY (n,o,q,w,z, bb,cc,dd)
Peerless Alloy Co., Colo (o,w)
Republic Metals Co., Inc., NY (n,o,w)
River Smelting & Refining Co., Ohio (w)
St. Joseph Lead Co., NY (n,o,w)
Sel-Rex Corp., NJ
(n)—Ad p 356
Stevens, Frederic B., Inc., Mich (n)
Triangle Conduit & Cable Co., Inc., NJ (ff)
Udylite Corp., Mich (n,bb,cc,ff)
United Refining & Smelting Co., Ill (n,o,q,w,z,bb,cc,dd,ff)
U.S. Smelting, Refining & Mining Co., NY (o,w,bb)

Calorized Coatings

(see Diffusion Coatings)

Carbides

(see Cermets, Refractories and specific metal)

Carbon, Graphite

Aerojet-General Corp., Structural Materials Div., Calif (r)
American Metal Products Co., Mich (bb,cc,dd,ee)
Becker Bros. Carbon Co., Ill (r,z,aa, bb,cc,ee)
Black Bear Co., Inc., NY (aa)
Blaco Mfg. Co., Ohio (aa)
Carbone Corp., NJ (r)
Dixon, Joseph Crucible Co., NJ (z, aa,bb)
Electro Chemical Engineering & Mfg. Co., Pa (r)
Gibson Electric Co., Pa (r,aa)
Graphite Metallizing Corp., NY (r)
Graphite Products Corp., Ohio (aa)
Graphite Specialties Corp., NY
(r,bb,ee)—Ad p 309
Great Lakes Carbon Corp., NY (r,z,bb)
Heil Process Equipment Corp., Ohio (r)
Henrite Products Corp., Ohio (r)
Hofford Varnish Co., Inc., NJ (r)
Industrial Tectonics, Inc., Mich (r)
Markal Co., Ill (z)
McGee Chemical Co., Inc., Pa (aa)
Metallized Carbon Co., NY (r)
Morganite, Inc., NY (r,bb,ee)
National Carbon Co., Div. of Union Carbide Corp., NY
(r,s,z,aa,bb,ee)—Ad p 307
Ohio Carbon Co., Ohio
(r,z,aa,bb,cc,ee)—Ad p 322
Pure Carbon Co., Inc., Pa (bb)
Russell Mfg. Co., Conn (r,s)
St. Marys Carbon Co., Pa (r,z)
Servwell Products Co., Ohio (aa)
Smith Chemical & Color Co., Inc., NY (aa)
Speer Carbon Co., Pa
(r)—Ad p 318
Stackpole Carbon Co., Pa
(r,z,bb,ee)—Ad p 320
Superior Carbon Products, Inc., Ohio (r)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

United Carbon Products Co., Mich (r, z,aa,bb,cc,ee)
U.S. Graphite Co., Div. of Wickes Corp., Mich (r)
U.S. Polymeric Chemicals, Inc., Conn (s)

Carbon Steel

(see Steel)

Casting Resins

(see specific plastic or rubber)

Castings, Centrifugal

Al-Fin Div., Arthur Tickle Engineering Works, Inc., NY (a,e)
Ali Metals Precision Casting Corp., NY (a,b,g)
Allegheny Ludlum Steel Corp., Pa (g)
Alloy Precision Castings Co., Ohio (a, b,c,e,f)
American Brake Shoe Co., NY (a,b,j)
American Cast Iron Pipe Co., Ala
(a,c,f,g)—Ad p 410
American Crucible Products Co., Ohio (b)
Ampco Metal, Inc., Wis (b)
Asco Sintering Corp., Calif (a,b)
Baldwin-Lima-Hamilton Corp., Pa (a, b,f)
Bendix Foundries Div., Bendix Aviation Corp., NJ (a,e)
Blaw-Knox Co., Pa (f,g)
Buckeye Brass & Mfg. Co., Ohio (a)
Bunting Brass & Bronze Co., Ohio (b)
Calorizing Co., Pa (f,g)
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich (c,g)
Centrifugal Casting Co., Calif (c,f,g)
Centrifugal Casting Co., NY (a,b,e,f, h,j)
Centrifugal Casting Machine Co., Okla (a,b)
Centr-O-Cast & Engineering Co., Mich (a)
Comet Metal Products Co., Inc., NY (d)
Cooper Alloy Corp., NJ (g)
Copper & Brass Sales Inc., Mich (b)
Curtiss-Wright Corp., Metal Processing Div., NY (g)
Cyril Bath Co., Ohio (g)
Dayton Foundry, Calif (c)
Derby Castings Co., Conn (a,b)
Division Lead Co., Ill (d)
Duraloy Co., Pa
(f,g)—Ad p 417
Electric Steel Foundry Co., Ore (f,g,h)
Electro-Alloys Div., American Brake Shoe Co., Ohio (g)
Engineered Castings Div., American Brake Shoe Co., NY (c,g)
Florence Pipe Foundry & Machine Co., NJ (c)
Frasse, Peter A. & Co., Inc., NY (g)
General Alloys Co., Mass (f)
General Electric Co., Foundry Dept., NY (a,b)
Haynes Stellite Co., Div. of Union Carbide Corp., Ind (f)
Hi-Grade Alloy Corp., Ill (d,j)
Hughes Tool Co., Tex (g)
Humphrey Castings, Inc., Calif (a,b,f, g)
Illinois Precise Casting Co., Ill (a, b,f,g)
International Nickel Co., Inc., NY (f)
Janney Cylinder Co., Pa (a,b,c,f)
Johnson Bronze, Pa (b)
Kay-Brunner Steel Products, Inc., Calif (g)
Kelsey-Hayes Co., Metals Div., NY (f)
Lebanon Steel Foundry, Pa (g)
Linton Precision Casting Co., Ind (a, b,c,f,g,j)
Magnolia Metal Co., NJ (b)
Mallory, P.R. & Co., Inc., Ind (b)
McCarter Iron Works, Inc., Pa (c,g)
Meehanite Metal Corp., NY
(c)—Ad p 461
Metal Goods Corp., Mo (a,b,c,f)
Metals Processing Div., Curtiss-Wright Corp., NY (f,g)
Milwaukee Aluminum & Brass Foundry, Wis (a,b)
Misco Precision Casting Co., Mich (c, f,g)
Moccasin Bushing Co., Tenn (b)
National Bearing Div., American Brake Shoe Co., Pa (b)
National Lead Co., NY (b,d)
National Lead Construction Co., Inc., NJ (l)
Ohio Steel Foundry Co., Ohio (f)
Oil City Iron Works, Tex (c)
Olds Alloy Co., Calif (a,b,d,f)
Oregon Metallurgical Corp., Ore (h)
Precision Castparts Corp., Ore (b,f,g)
Precision Founders, Inc., Calif (a,b,c,f, g,j)
Precision Metalsmiths, Inc., Ohio (a, b,c,d,f,g)
Quality Electric Steel Castings, Inc., Tex (g)
Rockwell Engineering Co., Ill (a,b,c,g)
Ryerson, Joseph T. & Sons, Inc., Ill (g)
Saginaw Bay Industries, Inc., Mich (a,e)
Sandusky Foundry & Machine Co., Ohio
(b,f,g)—Ad p 427
Schilling Bronze Co., NY (b,d,f,j)
Sheller Mfg. Corp., Mich (j)
Shenango Furnace Co., Centrifugally Cast Products Div., Ohio
(b,c,f)—Ad p 422
Sorbo-Mat Process Engineers, Mo (c)
State Foundry & Machine Co., Wis (c)
Staver Co., Inc., NY (d)
Swayne-Robinson & Co., Ind (a,c)
Terre Haute Bronze & Brass Foundry, Ind (b)
Thys Co., Calif (a,b,c,f,g)
True Alloys, Inc., Mich (a,b,d,j)
U.S. Pipe & Foundry Co., Ala (c,g)
Uniworld Research Corp. of America, Ohio (c)
Utica Drop Forge & Tool Co., NY (f, g)
Volirath Co., Wis (g)
Weatherhead Co., Ind (j)
West Steel Casting Co., Ohio (f)
Winters Foundry & Machine Co., Inc., Ohio (a,b)
Wisconsin Centrifugal Foundry, Inc., Wis (a,b,d,f,g)

Castings, Die

A & A Die Casting Co., Calif (j)
Able Tool & Engineering Co., Ill (a,j)
Accurate Die Casting Co., Ohio (a,e,j)
Accurate Metal Weather Strip Co., Inc., NY (j)
Admiral Die Castings Div., Portable Electric Tools, Inc., Ill (a,j)
Advance Pressure Castings, Inc., NY (a,j)
Advance Tool & Die Casting Co., Wis (a,j)
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (a,j)
Allen-Stevens Corp., NY (j)
Aluminum Co. of America, Pa (a)
Ambrit Industries, Inc., Calif (a,d,j)
American Aluminum Castings Co., NJ (a)
American Foundries Co., Mich (c)
American Foundry & Machine Div., Elmco Corp., Utah (g)
Auel Industries, Pa (j)
Auld, D.L. Co., Ohio (a,j)
Aurora Metal Co., Ill (b)
Badger Die Casting Corp., Wis (a,j)
Belmont Smelting & Refining Works, Inc., NY (a,d)
Bendix Foundries Div., Bendix Aviation Corp., NJ (a,e)
Briel Industries, Inc., Ind (a)
Brown Lipe Chapin Div., General Motors Corp., NY (j)
Centrifugal Casting Machine Co., Okla (a)
Centr-O-Cast & Engineering Co., Mich (a)
Century Die Casting Co., Ill (a,j)
Char-Lynn Co., Diecasting Div., Minn (a,j)
Chicago White Metal Casting, Inc., Ill (a,j)
Cincinnati Foundry Co., Ohio (c)
Comet Metal Products Co., Inc., NY (j)
Conneaut Die Casting Co., Ohio (a,j)
Continental Die Casting Corp., Mich (j)
Crown Metal Co., Wis (d)
Crucible Steel Co. of America, Pa (c,f,g)
Davis Products Corp., NY (j)
Dayton Bronze Bearing Co., Ohio (a,j)
Dayton Malleable Iron Co., Ohio (a)
Die Cast Products, Inc., Calif (a,j)
Diecast Corp., Mich (a,j)
Division Lead Co., Ill (d)
Doehler-Jarvis Div., National Lead Co., Ohio, (a,b,e,j)
Dollin Corp., NJ (a,d,j)
Dow Chemical Co., Dow Metal Products Co. Div., Mich (e)
Duane Specialties, Ltd., NJ (j)
Du-Wel Metal Products, Inc., Mich (a,j)
Eclipse-Pioneer Div., Bendix Aviation Corp., NJ (a,c)
Electric Autolite Co., Ohio (a,j)
Evans Metal Co., Ga (a,d,j)
Federal Die Casting Co., Ill (a)
General Electric Co., Foundry Dept., NY (b)
General Motors Corp., Fabricast Div., Ind (a)
Grammes, L.F. & Sons, Inc., Pa (j)
Grand Rapids Brass Co., Mich (j)
Grey, C.M. Industries, Inc., NJ (a,j)
Gries Reproducer Corp., NY (j)
Hamilton Die Cast, Inc., Ohio (a,j)
Hampden Brass & Aluminum Co., Mass (a,j)
Harbot Die Casting Corp., NJ (a)
Hardy Mfg. Corp., Ind (j)
Harvey Aluminum Sales, Inc., Calif (a)
Harvill Corp., Calif (a,b,e,j)
Hercules Fastener Co., Ill (j)
Hilfinger Corp., Ohio (j)
Hoover Co., Die Casting Div., Ohio (a, j)
Humphrey Castings, Inc., Calif (a)
Jersey Plastic & Die Casting Co., NJ (a,j)
Jervis Corp., Mich (a,j)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Kamin Die Casting & Mfg. Co., Ill (a,j)
Kent Castings Corp., Mich (j)
Kiowa Corp., Iowa (a,j)
Krone, Paul Die Casting Co., Ill (a,j)
La France Precision Casting Co., Pa (j)
Lake Erie Foundry Co., NY (c)
Latrobe Die Casting Co., Pa (a,d,j)
Lester Castings, Inc., Ohio (a,j)
Light Metals, Inc., Ind (a,e)
Litemetal Dicast, Inc., Mich (e)
Littlestown Hardware & Foundry Co., Inc., Pa (a)
Livingston-Tyler Products, Ohio (j)
Madison Kipp Corp., Wis (a,j)
Magline Inc., Mich (a,e)
Mallory, P.R. & Co., Inc., Ind (b,h)
Manor Die Cast Corp., Ohio (a)
Meehanite Metal Corp., NY
(c)—Ad p 461
Meta-Mold Aluminum Co., Sub. of Dayton Malleable Iron Co., Wis (a,e)
Milwaukee Die Casting Co., Wis (a,d,j)
Missouri Diecasting Co., Mo (a,j)
Model Brass Co., Inc., Ill (a,b)
Mohawk Foundries, Inc., Ohio (a)
Moldcast Products, Inc., NJ (a)
Monarch Aluminum Mfg. Co., Ohio (a,j)
Monarch Tool & Mfg. Co., Ky (j)
Mt. Vernon Die Casting Corp., Conn (a)
National Die Casting Co., Ill (a,j)
National Lead Co., NY (a,b,d,e,j)
National Lead Construction Co., Inc., NJ (d)
National Lock Co., Ill (j)
National Malleable & Steel Castings Co., Ohio (j)
National Supply Co., Pa (g)
New England Die Casting Co., Conn (a,j)
New Jersey Zinc Co., NY
(j)—Ad pp 452-453
New Products Corp., Mich (a,e,j)
Newton-New Haven Co., Conn (a,j)
Norgren-Stemac, Inc., Colo (j)
Olderman Mfg. Corp., Conn (j)
Paragon Die Casting Co., Ill (a,j)
Paramount Die Casting Co., Mich (a, e,j)
Parker White Metal Co., Pa (a,d,f,j)
Peasley Products, Inc., Conn (a,j)
Phoenix Die Casting Co., NY (a,j)
Pittsburgh Die & Casting Co., Pa (a,j)
Pressure Castings, Inc., Ohio (a,j)
Production Die Casting Co., Tex (a,e,j)
Rangers Die Casting Co., Calif (a,j)
Republic Die Casting Co., Mo (a,j)
Republic Metals Co., Inc., NY (d)
Rockwell Engineering Co., Ill (a,b,c,g)
Rupert Diecasting Co., Mo (a,j)
Ryerson, Joseph T. & Sons, Inc., Ill (a,g)
St. Louis Diecasting Corp., Mo (a,j)
St. Marys Foundry Co., Ohio (c)
Sargent & Greenleaf, Inc., NY (a,j)
Schilling Bronze Co., NY (a,b,d,f,j)
Schneider, Bowman Co., Inc., Pa (c)
Schultz Die Casting Co., Ohio (a,j)
Sillcocks Miller Co., NJ (a,c,d,j)
Southern Metal Products Co., La (a)
Star Heel Plate Co., Inc., NJ (a,j)
Staver Co., Inc., NY (d)
Stella Products Corp., NJ (j)
Sterling Die Casting Co., NY (a,j)
Stewart-Warner Corp., Stewart Die Casting Div., Ill (a,e,j)
Stoody Co., Calif (a,b,d,e)
Superior Die Casting Co., Ohio (a,j)
Thompson Products, Light Metals Div., Ohio (a)
Titan Metal Mfg. Co., Pa (b)
Tower Grove Foundry, Mo (c)
Twin City Die Casting Co., Minn
(a,d,j)—Ad p 418
Veeder-Root, Inc., Conn (j)
Vulcan Rail & Construction Co., NY (a,c,g)
Weber-Knapp Co., NY (a)
West Irving Die Casting Co., Ill (a)
Westland Die Casting, Inc., Calif (a,j)
Wheaton Die Casting Corp., NJ (a,j)

Castings, Investment

Aerojet-General Corp., Structural Materials Div., Calif (a)
All Metals Precision Casting Corp NY (a,b,g)
Alloy Precision Castings Co., Ohio (a b,c,e,f,g)
Arwood Corp., NY (a,b,e,g)
Atlantic Casting Engineering Corp., NJ (a,b)
Austenal Co., Div. of Howe Sound Co., NY (a,c,f,g)
Bone Engineering Corp., Calif (a,b,f,g)
Buckeye Brass & Mfg. Co., Ohio (a, b,c,g)
Casting Engineers, Inc., Ill (a,b,c,f,g)
Centrifugal Casting Co., NY (a,b,e,f, h,j)
Chrysler Corp., Mich (a,b,c,e,f,g,h,j)
Electric Steel Foundry Co., Ore (h)
Electronicast Div., Nilsen Mfg. Co., Ill (a,b,c,e,f,g,h,j)
Engineered Precision Casting Co., NJ (a,b,c,f,g)

Suppliers of Materials

General Motors Corp., Fabricast Div., Ind (a,f)
Gray-Syracuse, Inc., NY (a,b,c,f,g)
Harcast Co., Inc., Pa (a,b,c,f,g)
Haynes Stellite Co., Div. of Union Carbide Corp., Ind (c,f,g)
Hawkridge Bros. Co., Mass (a,b,c,e,f,g,h,j)
Hitchiner Mfg. Co., Inc., NH (a,b,c,f,g)
Howard Foundry Co., Ill (a,b,c,f,g)
Humphrey Castings, Inc., Calif (a,b,f,g)
Illinois Precise Casting Co., Ill (a,b,f,g)
International Nickel Co., Inc., NY (f)
Investment Casting Co., NJ (a,b,c,f,g)
Jelrus Precision Casting Corp., NY (a,b,c,e,f,g,h,j)
Joseff-Hollywood Co., Calif (a,b,c,g)
Kolcast Industries Div., Thompson Products, Inc., Ohio (a,c,f,g)
Lawrence Laboratory, Calif (a,b,e)
Lebanon Steel Foundry, Pa (g)
Linton Precision Casting Co., Ind (a,b,c,f,g,j)
Loeffler, J. M. Machine Co., Pa (b)
Lynn Casting Corp., Calif (a,b,d,f,g)
Manco Products, Inc., Mich (f,g)
Meehanite Metal Corp., NY
(c)—Ad p 461
Mercast Mfg. Corp., Calif (a,b,c,e,f,g)
Metal Goods Corp., Tex (f)
Midwest Precision Castings Co., Ohio (a,b,c,f,g)
Misco Precision Casting Co., Mich (c,f,g)
National Precision Casting Corp., Div. of Beryllium Corp., Pa (a,b,c,f,g)
Omni-Metal Castings, Inc., NY (a, b,c,f,g)
Oregon Metallurgical Corp., Ore (h)
Picco, Inc., Calif (a,b,c,f,g)
Precision Castparts Corp., Ore (b,f,g)
Precision Founders, Inc., Calif (a, b,c,f,g,j)
Precision Metalsmiths, Inc., Ohio (a, b,c,d,f,g)
Rausch Mfg. Co., Inc., Minn (a,b)
Rockwell Engineering Co., Ill (a,b,c,g)
Rode, Inc., Mass (a,b)
Rolle Mfg. Co., Pa (a,b,e,f,g)
Solon Foundry, Inc., Ohio (a,e)
Star Heel Plate Co., Inc., NJ (a,b)
Staver Co., Inc., NY (d)
Thompson, K.W. Tool Co., NY (a,b, c,e,f,g,h,j)
Thys Co., Calif (a,b,c,f,g)
United Shoe Machinery Corp., Mass (g)
Uniworld Research Corp. of America, Ohio (c,f)
Vascoloy-Ramet Corp., Ill (b,g)
Wall Colmonoy Corp., Stainless Process Div., Mich (c,f)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (a,b,c,f,g,h)
York Casting, Inc., NY (a,b,c,e,f,g, h,j)
Z & H Mfg. Co., NY (a,b,c,e,f,g,h,j)

Castings, Nonmetallic

(plastics and rubber)

Ace Plastic Co., NY (l)
Acushnet Process Co., Mass (m)
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (k,l)
Allied Resinous Products, Inc., Ohio (k)
American Agile Corp., Ohio (k)
Amos Molded Plastics Div., Amos-Thompson Corp., Ind (k)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Auburn Plastic Engineering, Ill (k)
Automotive Rubber Co., Inc., Mich (m)
Biggs, Carl H. Co., Inc., Calif (k,l)
Boonton, Molding Co., NJ (k,l,m)
Buckeye Molding Co., Ohio (k)
Cadillac Plastic & Chemical Co., Mich (k)
Campro Co., Ohio (k)
Cast Optics Corp., NJ (k,l)
Ceilcote Co., Ohio (l)
Chemical Coatings & Engineering Co., Pa (k,l,m)
Chemical Development Corp., Mass (l)
Conneaut Rubber & Plastics Co., Div. of U.S. Stoneware Co., Ohio (k)
Disogrin Industries, Inc., NY (m)
Douglas & Sturgess, Calif (l,m)
Duriron Co., Inc., Ohio (l)
Eby, Hugh H. Co., Pa (k,l)
Eclipse Plastic Industries, Inc., Fla (k)
Electric Auto-Lite Co., Ohio (k,l)
Electronic Production & Development, Inc., Chemical Div., Calif (k)
Eljay Corp., Md (l)
Emerson & Cuming, Inc., Mass (k,l,m)
Foss Mfg. Co., Id (l)
Fry Plastics International, Calif (k,l)
General Mills, Inc., Chemical Div., Ill (k,l)
Goodrich, B.F. Industrial Products Co., Ohio (k)
Grimes Mfg. Co., Plastic Research Products, Ohio (l)
Hays Mfg. Co., Pa (l)
Hysol Corp., NY (l)
Kerrco, Neb (k,l,m)
Kurz Kasch, Inc., Ohio (l)
Madin Plastics Inc., NJ (k)
Marblette Corp., NY (l)
Mechanical Rubber Products Co., NY (l)
Minnesota Rubber & Gasket Co., Minn (k,m)
Mobay Chemical Co., Pa (m)
Munray Products Div., Fanner Mfg. Co., Ohio (k,m)
New England Tape Co., Div. of United-Carr Fastener Corp., Mass (l)
Polymer Corp. of Pennsylvania, Sub. of Polymer Corp., Pa (k)
Pyrosil, Inc., Ohio (l)
Quelcor, Inc., Pa (k)
Reinhold Engineering & Plastics Co., Inc., Calif (l)
Ren Plastics, Inc., Mich (l)
Sewell Mfg. Co., Mich (l)
Sierra Electric Corp., Calif (k,l)
Superior Plastics, Inc., Ill (k)
Sylvania Electric Products, Inc., Parts Div., Pa (k,l)
Thombert, Inc., Iowa (l,m)
Trostel, Albert Packing, Ltd., Wis (l)
Tuff Clad, Inc., Ohio (k)
U.S. Stoneware Co., Ohio (k)

Castings, Permanent Mold

A C F Industries, Inc., NY (e)
Abco Aluminum & Brass Works, Tex (a,d)
Acme Aluminum Foundry Co., Ill (a)
Advance Aluminum Castings Corp., Ill (a)
Al-Fin Div., Arthur Tickle Engineering Works, Inc., NY (a,e)
Aluminum Alloys Corp., Mich (a)
Aluminum Co. of America, Pa (a)
Aluminum Casting & Engineering Co., Wis (a,j)
Aluminum Industries, Inc., Ohio (a)
Aluminum Permanent Mold Co., Mich (a)
American Aluminum Castings Co., NJ (a)
American Brake Shoe Co., NY (a,b, c,g,j)
American Metal Climax, Inc., NY (b)
Apex Steel Corp., Ltd., Calif (g)
Baldt Anchor, Chain & Forge Div., Boston Metals Co., Pa (a,b)
Belmont Smelting & Refining Works, Inc., NY (a,d,j)
Bendix Foundries Div., Bendix Aviation Corp., NJ (a,e)
Bohn Aluminum & Brass Corp., Mich (a)
Briggs-Shaffner Co., NC (a)
Bronze & Steel Die Casting Co., Ill (b)
Buckeye Brass & Mfg. Co., Ohio (a, b,j)
Bunker Hill Co., Calif (d,j)
Bunting Brass & Bronze Co., Ohio (a,b)
Calumet Div., Calumet & Hecla, Inc., Mich (c)
Centrifugal Casting Machine Co., Okla (a)
Centr-O-Cast & Engineering Co., Mich (a)
Chattanooga Aluminum Foundry, Inc., Tenn (a)
Cochrane Foundry, Inc., Pa (a,b,j)
Crobalt, Inc., Mich (g)
Crown Metal Co., Wis (d)
Davis Products Corp., NY (j)
Dayton Malleable Iron Co., Ohio (a)
Derby Castings Co., Conn (a)
Dirilyte Co. of America, Inc., Ind (b)
Division Lead Co., Ill (d)
Dixie Bronze Co., Ala (a,b,f)
Dostar Foundry & Machine Co., Mich (c)
Dow Chemical Co., Dow Metal Products Co. Div., Mich
(e)—Ad pp 408-409
Eaton Mfg. Co., Foundry Div., Mich
(c)—Ad p 459
Eclipse-Pioneer Div., Bendix Aviation Corp., NJ (a,e)
Electric Steel Foundry Co., Ore (f,g)
Enterprise Wheel & Car Corp., Va (a)
Est Co., Inc., Wis (a,e)
Exalco Mfg. Co., Ohio
(a)—Ad p 420
Fairfield Aluminum Casting Co., Iowa (a)
Flynn, Michael Mfg. Co., Pa (a)
Forest City Foundries Co., Ohio (c)
Foster Aluminum Alloy Products Corp., NY (a)
General Aluminum Mfg. Co., Ohio (a,e)
General Electric Co., Foundry Dept., NY (c)
General Motors Corp., Fabricast Div., Ind (a)
Gilbert Brass & Foundry Co., Mo (a)
Gillett & Eaton, Inc., Minn (a,c)
Hampden Brass & Aluminum Co., Mass (a)
Harvill Corp., Calif (a,e)
Howard Foundry Co., Ill (a,e)
Humphrey Castings, Inc., Calif (a)
Johnson Bronze Co., Pa (b)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Lebanon Steel Foundry, Pa (g)
Light Metals, Inc., Ind (a,e)
Light Metals Dept., American Brake Shoe Co., NJ (a,e)
Littlestown Hardware & Foundry Co., Inc., Pa (a)
Magline, Inc., Mich (a,e)
Magnolia Metal Co., NJ (b)
Mallory, P.R. & Co., Inc., Ind (h)
Manco Products, Inc., Mich (b)
Manor Die Cast Corp., Ohio (a)
Mansfield Brass & Aluminum Corp., Ohio (a)
Marshall Car & Wheel Foundry Co., Inc., Tex (c)
McLanahan & Stone Corp., Pa (c)
Meehanite Metal Corp., NY
(c)—Ad p 461
Metal Mold Magnesium Corp., Wis (e)
Meta-Mold Aluminum Co., Sub of Dayton Malleable Iron Co., Wis (a,e)
Moccasin Bushing Co., Tenn (b)
Mohawk Foundries, Inc., Ohio (a)
Moldcast Products, Inc., NJ (a)
Monarch Aluminum Mfg. Co., Ohio (a)
Morse, Fred W. Co., RI (a,j)
National Aluminum Mfg. Co., Ill (a)
National Lead Construction Co., Inc., NJ (d)
Nuclear Metals, Inc., Mass (a,b,c,e,f, g,h)
Olds Alloys Co., Calif (b,d,f)
Oregon Metallurgical Corp., Ore (h)
Parker, Charles Co., Conn (a,j)
Peasley Products, Inc., Conn (a,j)
Permold Co., Ohio (a)
Philadelphia Bronze & Brass Corp., Pa (a,b,f)
Quality Aluminum Casting Co., Wis (a)
Rockwell Engineering Co., Ill (a,b,c,g)
Rolle Mfg. Co., Pa (a,e)
Saginaw Bay Industries, Inc., Mich (a,e)
Sandusky Foundry & Machine Co., Ohio (b,f,g)
Schilling Bronze Co., NY (a,b,d,f,j)
Schmeller Aluminum Foundry Co., Ohio (a)
Skookum Co., Inc., Ore (g)
Sorbo-Mat Process Engineers, Mo (c)
Standard Magnesium Corp., Okla (e)
Star Heel Plate Co., Inc., NJ (a,b)
Staver Co., Inc., NY (d)
Sterling Aluminum Products, Inc., Mo (a)
Stewart-Warner Corp., Stewart Die Casting Div., Ill (a)
Superb Light Alloys, Inc., NY (a,e)
Texas Foundries, Inc., Tex (c,g)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Thompson Products, Light Metals Div., Ohio (a)
Tickle, Arthur Engineering Works, Inc., NY (a)
True Alloys, Inc., Mich (a,b,d,j)
Universal Castings Corp., Ill (a,b)
Vulcan Rail & Construction Co., NY (a,c)
Waterman Industries, Inc., Calif (a)
Wellman Bronze & Aluminum Co., Ohio (a,e)
Williams, A.C. Co., Ohio (e)
Winters Foundry & Machine Co., Inc., Ohio (a)
Wisconsin Aluminum Foundry Co., Inc., Wis (a,b)

Castings, Plaster Mold

Aerojet-General Corp., Structural Materials Div., Calif (a)
Al-Fin Div., Arthur Tickle Engineering Works, Inc., NY (a,e)
All Metals Precision Casting Corp., NY (a,b)
Alloy Precision Castings Co., Ohio (a, b,c,e,f,g)
Aluminum Co. of America, Pa (a)
American Aluminum Casting Co., NJ (a)
Atlantic Casting Engineering Corp., NJ
(a,b)—Ad p 438
Bean, Morris & Co., Ohio (a)
Beloit Foundry Co., Ill (c)
Bendix Foundries Div., Bendix Aviation Corp., NJ (a)
Chattanooga Aluminum Foundry, Inc., Tenn (a)
Curtiss-Wright Corp., NY (g)
Derby Castings Co., Conn (a)
Eclipse-Pioneer Div., Bendix Aviation Corp., NJ (a,e)
General Motors Corp., Fabricast Div., Ind (a)
Hampden Brass & Aluminum Co., Mass (a)
Humphrey Castings, Inc., Calif (a)
Larson, W. O. Foundry Co., Ohio (c)
Lebanon Steel Foundry, Pa (g)
Light Metals Dept., American Brake Shoe Co., NJ (a)
Lincoln Foundry Corp., Calif (c)
Loeffler, J. M. Machine Co., Pa (b)
Meehanite Metal Corp., NY
(c)—Ad p 461
Mercast Mfg. Corp., Calif (a,b,c,e, f,g)
Ohio Precision Castings, Inc., Ohio (a,b,f)
Olderman Mfg. Corp., Conn (b)
Oregon Metallurgical Corp., Ore (h)
Rockwell Engineering Co., Ill (a,b,c,g)
Ross-Meehan Foundries, Tenn (c,g)
Schilling Bronze Co., NY (a,b,d,f,j)
Schneider, Bowman Co., Inc., Pa (c)
Solon Foundry, Inc., Ohio (a,e)
Sorbo-Mat Process Engineers, Mo (c)
True Alloys, Inc., Mich (a,b)
Universal Castings Corp., Ill (a,b)
Wayne Foundry & Stamping Co., Mich (j)
Western Iron & Foundry Co., Inc., Kan (c)

Castings, Sand

Abco Aluminum & Brass Works, Tex (a,b,d,f,j)
Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa (b, c,g)
Acme Aluminum Foundry Co., Ill (a)
Acme Foundry & Machine Co., Kan (c)
Acme Foundry & Machine Co., Okla (c)
Advance Foundry Co., Ohio (c)
Aelco Foundries, Inc., Wis (a,b,d,e, f,g)
Albany Car Wheel Co., Inc., NY (c)
Albert Lea Foundry-Queen Products Div., King-Seeley Corp., Minn (c)
Albion Malleable Iron Co., Mich (c)
Alcasco Foundry, Ill (a,b)
Al-Fin Div., Arthur Tickle Engineering Works, Inc., NY (a,e)
Allegheny Foundry Co., Pa (c)
Allegheny Ludlum Steel Corp., Pa (g)
Allied Steel Castings Co., Ill (g)
Alloy Cast Steel Co., Ohio (g)
Alloy Steel Casting Co., Pa (f,g)
Almont Mfg. Co., Mich (c)
Alten Foundry & Machine Works, Inc., Ohio (c)
Aluminum Alloys Corp., Mich (a)
Aluminum Co. of America, Pa (a,e)
Aluminum Industries, Inc., Ohio (a)
Aluminum Permanent Mold Co., Mich (a)
Amalgamated Steel Corp., Ohio (g)
American Aluminum Casting Co., NJ (a)
American Brake Shoe Co., NY (a, b,j)
American Car & Foundry Div., ACF Industries, Inc., NY (c)
American Cast Iron Pipe Co., Ala (c,f,g)
American Crucible Products Co., Ohio (b)
American Foundries Co., Mich (c)
American Laundry Machinery Co., NY (c)
American Light Alloys, Inc., NJ (a, e)
American Manganese Steel Div., American Brake Shoe Co., Ill (g)
American Metal Climax, Inc., NY (b)
American Sanitary Mfg. Co., Ill (b)
American Steel Foundries, Ind (g)
American Steel Foundries, Ill (g)
Ampco Metal, Inc., Wis (b)
Apex Foundry, Inc., Mich (c,e,f)
Apex Steel Corp., Ltd., Calif (g)
Arkansas Foundry Co., Ark (c)
Arneson Foundry Co., Wis (c,g)
Arnold Engineering Co., Ill (a,c,f)
Arzt, T.L. Foundry Co., Ill (c)
Atlantic Foundry Co., Ohio (c,g)
Atlantic Steel Castings Co., Pa (g)
Atlas Brass Foundry, Calif (b)
Atlas Foundry Co., Ohio (c)
Atlas Foundry & Machine Co., Wash (c,g)
Atlas Foundry & Mfg. Co., Calif (c)
Auto Specialties Mfg. Co., Mich (c)
Badger Malleable & Mfg. Co., Wis
Baldwin-Lima-Hamilton Corp., Pa (a, b,f,g)
Banner Iron Works, Mo (c)
Barnard Foundry Co., Inc., Mass (b)
Barnett Foundry & Machine Co., NJ (c)
Baxter Foundry & Machine Works, Inc., Id (a,b,c)
Bay City Electric Steel Casting Co., Mich (g)
Bay City Foundry Co., Mich (c)
Bay State Tool & Machine Co., Mass (g)
Bean, Morris & Co., Ohio (c)
Bearium Metals Corp., NY (b)
Beaver Valley Alloy Foundry Co., Pa (c,g)
Bellaire Stove Co., Ohio (c)
Belle City Malleable Iron Co., Wis (c)
Beloit Foundry Co., Ill (c)
Bendix Foundries Div., Bendix Aviation Corp., NJ (a,e)
Beryllium Corp., Pa (b)
Bethlehem Steel Co., Pa (c,g)
Bierman-Everett Foundry Co., NJ (a, b,c)
Bignall Co., NY (c)
Black-Clawson Co., Ohio (c)
Blaw-Knox Co., Pa (f,g)
Bond, Charles Co., Pa (c)
Bonnot Co., Ohio (c)
Briggs-Shaffner Co., NC (a,c)
Brinkerhoff Brass & Bronze Works, Inc., NY (a)
Bruce Foundry and Mfg. Co., Mich (c)
Buckeye Iron & Brass Works, Ohio (a,b)
Bunting Brass & Bronze Co., Ohio (b)
Butler Engine & Foundry Co., Inc., Pa (a,b,c)
Cadillac Malleable Iron Co., Mich (c)
Calorizing Co., Pa (f,g)
Calumet Div., Calumet & Hecla, Inc., Mich (c)
Calumet Steel Castings Corp., Ind (g)
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich (c,g)
Canton Malleable Iron Co., Ohio (c)
Carondelet Foundry Co., Mo (c,f,g)
Case, J.I. Co., Wis (c)
Castalloy Co., Inc., Mass (a,e)
Casting Service Corp. of Michigan, Mich (c)
Central Casting Div., King-Seeley Corp., Mich (c)
Chain Belt Co., Wis (c)
Chambersburg Engineering Co., Pa (c)
Chattanooga Aluminum Foundry, Inc., Tenn (a)
Chicago Aluminum Castings, Ill (a)
Chicago Hardware Foundry Co., Ill (a,b,c)
Chicago Malleable Castings Co., Ill (c)
Cincinnati Foundry Co., Ohio (c)
Clark Bros. Co. Div., Dresser Operations, Inc., NY (c)
Clarksville Foundry & Machine Works, Tenn (c)
Cleveland Foundry & Mfg. Co., Inc., Tenn (c)
Clinton Metal Products Co., Ohio (a)
Cochrane Foundry, Inc., Pa (a,b,j)
Columbian Bronze Corp., NY (a,b,d)
Columbiana Pump Co., Ohio (c)
Commercial Iron Works, Calif (c)
Commercial Steel Casting Co., Ohio (g)
Compton Foundry, Calif (c)
Continental Gin Co., Ala (c)
Cooper Alloy Corp., NJ (g,h)
Cooper-Bessemer Corp., Ohio (c) (a,b)
Copper & Brass Sales, Inc., Mich (c)
Crawford & Doherty Foundry Co., Ore (c)
Crown Non-Ferrous Foundry, Inc., Pa (a,b,f)
Crucible Steel Casting Co., Pa (g)
Curtiss-Wright Corp., Metals Processing Div., NY (f,g)
Dalton Foundries, Inc., Ind (c)
Darling Valve & Mfg. Co., Pa (c)
Dayton Bronze Bearing Co., Ohio (a,b)
Dayton Foundry, Calif (c)
Dayton Malleable Iron Co., Ohio (a, c)
Decatur Casting Co., Ind (c)
Decrow Engineering Corp., NY (a,b)
De Laval Steam Turbine Co., NJ (c)
Derby Castings Co., Conn (a,b)
De Sanno Foundry & Machine Co., Calif (a,b)
Detroit Brass & Malleable Co., Mich (c)
Deuscher, H.P. Co., Ohio (c)
Dexter Foundry Div., Philco Corp., Iowa (c)
Dirilyte Co. of America, Inc., Ind (b)
Division Lead Co., Ill (d)
Dixie Bronze Co., Ala (a,b,f)
Dodge Steel Co., Pa (g)
Dormont Mfg. Co., Pa (b)
Dow Chemical Co., Dow Metal Products Co. Div., Mich
(e)—Ad pp 408-409
Driver-Harris Co., NJ (f)
Ductile Iron Foundry, Inc., Conn (c)
Duluth Brass Works Co., Minn (a,b)
Duraloy Co., Pa
(g)—Ad p 417
Duriron Co., Inc., Ohio (c,g)
East Birmingham Bronze Foundry Co., Ala (a,b)
Eastern Malleable Iron Co., Del (g)
Eclipse-Pioneer Div., Bendix Aviation Corp., NJ (a,e)
Ehrsam, J.B. & Sons Mfg. Co., Kan (c)
Elchinger, Charles F., La (a,b)
Electric Materials Co., Pa (b)
Electric Steel Foundry Co., Ore (f,g)
Electro-Alloys Div., American Brake Shoe Co., Ohio (g)
Electron Corp., Colo (c,f)
Elk Engineering Works, Inc., Pa (a,b,c)
Elkhart Foundry & Machine Co., Inc., Ind (c)
Elkhart Iron Works, Mich (c)
Elyria Foundry Div., Chromalloy Corp., Ohio (c)
Emmaus Foundry & Machine Co., Pa (a,b,c)
Empire Foundry Co., Inc., Calif (c,g)
Empire Steel Castings, Inc., Pa (g)
Engineered Castings Div., American Brake Shoe Co., NY (c)
Enterprise Wheel & Car Corp., Va (a, b,c)
Erie Bronze Co., Pa (a,b)
Erie Casting Co., Pa (c)
Erie Malleable Iron Co., Pa (c)
Eureka Electric Products Co., Pa (a,b)
Fahralloy Co., Ill (g)
Fairbanks, Morse & Co., Wis (c)
Fairfield Aluminum Castings Co., Iowa (a)
Falk Corp., Wis (g)
Federal Malleable Co., Wis (c)
Fischer Casting Co., Inc., NJ (a)
Fitchburg Foundry, Inc., Mass (c)
Flood City Brass & Electric Co., Pa (a,b)
Florence Pipe Foundry & Machine Co., NJ (c)
Florin Foundry & Mfg. Co., Pa (c)
Forest City Foundries Co., Ohio
Fort Pitt Steel Casting Div., Pittsburgh Steel Foundry Corp., Pa (f,g)
Fort Worth Steel & Machinery Co., Tex (c)
Foster Aluminum Alloy Products Corp., NY (a)
Frederick Iron & Steel, Inc., Md (c)
Fremont Casting Co., Mass (c)
Frontier Bronze Corp., NY (a,b,f)
Fulton Foundry & Machines Co., Inc., Ohio (c)
G & C Foundry Co., Ohio (c)
Gale Mfg. Co., Mich (c)
Gartland Foundry Co., Ind (c)
General Alloys Co., Mass (f)
General Electric Co., Foundry Dept., NY (a,b,c,f,g)
General Foundry & Mfg. Co., Mich (c)
General Malleable Corp., Wis (c)
General Metals Corp., Calif (c)
General Motors Corp., Central Foundry Div., Mich (c)
General Motors Corp., Fabricast Div., Ind (a)
General Steel Castings Corp., Ill (g)
Georgia Iron Works, Ga (c)
Gibson & Kirk Co., Md (a,b,f)
Gilbert Brass Foundry Co., Mo (a,b)
Gillett & Eaton, Inc., Minn (a,c)
Glover Machine Works, Ga (g)
Gluntz Brass & Aluminum Foundry Co., Ohio (a,b,j)
Goslin Birmingham Mfg. Co., Inc., Ala (c,g)
Gowanda Furnaces, Inc., NY (c)
Grafton Foundry Co., Wis (c)
Graham, James Co., Conn (b)
Gra-Iron Foundry Corp., Iowa (c)
Green Bay Foundry & Machine Works, Wis (a,b,c)
Greenlee Foundry Co., Ill (c)
Grimm Foundry Co., Inc., NJ (c)
Gunite Foundries Corp., Ill (c,g)
H & H Foundry Machine Co., Pa (c)
Hallstead Foundry, Inc., Pa (c)
Hamilton Foundry & Machine Co., Ohio (c)
Hampden Brass & Aluminum Co., Mass (a,b,j)
Hansell-Elcock, Ill (c)
Hardinge Mfg. Co., Pa (c)
Hartford Electrical Steel Corp., Conn (g)

Suppliers of Materials

Haynes Stellite Co., Div. of Union Carbide Corp., Ind (f)
Hays Mfg. Co., Pa (b)
Headford Bros. & Hitchins Foundry Co., Iowa (c)
Helmick Foundry-Machine Co., WVa (c)
Hewitt, John Foundry Co., NJ (a,b,c)
Hica, Inc., La (f,g)
Hills-McCanna Co., Ill (d)
Hobbs, Clinton E. Co., Mass (a,b,c)
Hodgson Foundry Co., Ill (a,b,c,d)
Hoffman Bronze & Aluminum Casting Co., Ohio (a,b)
Homestead Valve Mfg. Co., Pa (a,b,c,f)
Howard Foundry Co., Ill (a,b,c,e,f,g)
Humphrey Castings, Inc., Calif (a)
Hunt-Spiller Mfg. Corp., Mass (c,g)
I-F Mfg. Co., Ohio (c)
Illinois Iron & Bolt Co., Ill (a,f)
Independence Stove & Mfg. Co., Mo (c)
Indiana Brass Co., Inc., Ind (b)
Industrial-Ferguson Foundry Corp., NJ (a,b,f,j)
International Nickel Co., Inc., NY (f)
Iowa Malleable Iron Co., Iowa (c)
Ironton Malleable Div., Dayton Malleable Iron Co., Ohio (c)
Irwin-Sensenich Corp., Pa (c)
Jamestown Malleable Iron Corp., NY (c)
Jessop Steel Co., Pa (c,g)
Johnson Bronze Co., Pa (b)
Johnstone Foundries, Inc., Pa (c)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Kanawha Mfg. Co., W. Va (c)
Kansas City Hay Press Co., Mo (c)
Kay-Brunner Steel Products, Inc., Calif (g)
Keen Foundry Co., Inc., Ind (c)
Kelly Foundry Co., Pa (c)
Kingsport Foundry & Mfg. Corp., Tenn (a,b,c,f)
Klinzing, A.F. Co., Inc., Wis (c,g)
Koehring Co., Wis (c)
Kramer Bros. Foundry Co., Ohio (c)
Kutztown Foundry & Machine Corp., Pa (c)
L F M Mfg. Co., Inc., Sub. of Rockwell Mfg. Co., Kan (g)
Laconia Malleable Iron Co., NH (c)
Lake Erie Foundry Co., NY (c)
Lakeside Bronze, Inc., NY (a,b)
Lakeside Malleable Casting Co., Wis (c)
Langsenkamp-Wheeler Brass Works, Inc., Ind (a,b)
La Porte Foundry Co., Ind (c)
Larson, W.O. Foundry Co., Ohio (c)
Lattimer Foundry and Machine Co., Pa (a)
Lawrence Copper & Bronze Co., Pa (b)
Lawton, C.A. Co., Wis (a,c)
Lebanon Steel Foundry, Pa (g)
Le Baron, E.L. Foundry, Mass (c)
Lee Bros. Foundry Co., Inc., Ala (b)
Lehigh Foundries Co., Div. of Lehigh, Inc., Pa (c)
Leitelt Bros., Inc., Ill (a,b)
Letukas Foundry Inc., Ind (c)
Lewistown Foundry & Machine Co., Pa (a,c,d)
Liberty Foundry Co., Mo (c,g)
Light Metals, Inc., Ind (a,e)
Light Metals Dept., American Brake Shoe Co., NJ (a)
Lincoln Foundry Corp., Calif (c)
Lincoln Iron Works, Vt (a,c,g)
Link-Belt Co., Ill (c)
Littite Foundries, Inc., Mich (c)
Littlestown Hardware & Foundry Co., Inc., Pa (a,b,c)
Lloyd & Scott Brass Foundry, Inc., Del (a,b)
Lodge Mfg. Co., Tenn (c)
Lodi Iron Works, Inc., Calif (c)
Loeffler, J. M. Machine Co., Pa (b)
Long Beach Iron Works, Calif (c)
Long Foundry Co., Wash (c)
Lorain Brass Co., Ohio (b)
Los Angeles Steel Casting Co., Calif (g)
Ludlow Valve Mfg. Co., Inc., NY (c)
Lumen Bearing Co., NY (b,d,j)
Lynchburg Foundry Co., Castings Div., Va (c)
Macaulay, H.C. Foundry Co., Calif (c)
Mackintosh-Hemphill Div., E.W. Bliss Co., Pa (g)
Madison Foundry Co., Ohio (c)
Magline, Inc., Mich (a,e)
Mallory, P.R. & Co., Inc., Ind (b,f,h)
Manco Products Inc., Mich (b)
Mansfield Brass & Aluminum Corp., Ohio (a,b)
Marshall Car Wheel & Foundry Co., Inc., Tex (c)
Massillon Steel Casting Co., Ohio (g)
McLanahan & Stone Corp., Pa (c)
McNally Pittsburgh Mfg. Co., Kan (c)
Meadville Malleable Iron Co., Pa (c)
Meehanite Metal Corp., NY (c)—Ad p 461
Merrimac Brass, Mass (a,b,d,e,f)
Merriman Bros., Inc., Mass (b)
Metal Goods Corp., Mo (f)
Metropolitan Iron Foundry, NY (a,c)
Midwest Foundry Co., Div. of L.A. Darling Co., Mich (c,g)
Midwestern Foundries, Inc., Ind (c)
Milwaukee Aluminum & Brass Foundry Wis (a,b)
Milwaukee Malleable & Grey Iron Works, Wis (c)
Milwaukee Valve Co., Wis (a,b)
Minneapolis Electric Steel Castings Co., Minn (g)
Missouri Steel Castings Co., Mo (g)
Moccasin Bushing Co., Tenn (b)
Model Brass Co., Inc., Ill (a,b)
Modern Brass Foundry & Mfg. Co., Ohio (a,b)
Mohawk Foundries, Inc., Ohio (a)
Moline Malleable Iron Co., Ill (c)
Monroe Steel Castings Co., Mich (g)
Montague Machine Co., Mass (b,c,f)
Moore Dry Dock Co., Calif (b,g)
Morrisville Foundry Co., Inc., Vt (c)
Morse, Fred W. Co., RI (a,j)
Mount Vernon Furnace & Mfg. Co., Ill (c)
Mueller Brass Co., Mich (a,b)—Ad p 455
Muskegon Piston Ring Co., Mich (b,c)
National Aluminum Co., Inc., Wis (a,b)
National Aluminum & Brass Foundry, Inc., Mo (a,b)
National Bearing Div., American Brake Shoe Co., Pa (b)
National Brass Works, Inc., Calif (a,b,d,f)
National Grey Iron Foundry, Ill (c)
National Malleable & Steel Castings Co., Ohio (c,g)
National Steel & Shipbuilding Corp., Calif (c)
National Supply Co., Pa (g)
Neenah Foundry Co., Wis (c)
Newman Bros., Inc., Ohio (a,b)
Noble & Wood Machine Co., NY (c)
North Wales Foundry Co., Inc., Pa (c)
Northern Malleable Iron Co., Minn (c)
Nutmeg Crucible Steel Co., Conn (g)
Oak Hill Foundry & Machine Works, Ohio (c)
Oakes Bronze & Aluminum Co., Ohio (a,b)
Oakland Foundry & Machine Co., Mich (c)
Ohio Malleable Div., Dayton Malleable Iron Co., Ohio (c)
Ohio Precision Castings, Inc., Ohio (a,b,f)
Ohio Steel Foundry Co., Ohio (f,g)
Oil City Iron Works, Tex (c)
Oklahoma Steel Castings Div., American Steel & Pump Corp., Okla (g)
Olderman Mfg. Corp., Conn (b)
Olds Alloys Co., Calif (a,b,d,f)
Olympic Steel Works, Wash (g)
Omaha Steel Works, Neb (g)
Oregon Brass Works, Ore (a,b)
Oregon Metallurgical Corp., Ore (h)
Overmyer Mould Co., Inc., Ind (c,f,g)
Owen Pattern Foundry & Mfg Co., Inc., Va (a,b)
Pacific Brass Foundry of San Francisco, Calif (a,b,d,f,j)
Pacific Foundry Co., Ltd., Calif (c,g)
Palmyra Foundry Co., Inc., NJ (c)
Parker, Charles Co., Conn (a,b)
Parker-Street Castings Co., Ohio (c)
Paulson, Thomas & Son, Inc., NY (a,b,f,j)
Payne, F.S. Co., Mass (c)
Pelton Steel Casting Co., Wis (g)
Penn Steel Castings Co., Pa (g)
Peoria Malleable Casting Co., Ill (c)
Pequonnock Foundry, Inc., Conn (c)
Perfecto Cast, Calif (f,g)
Perkins, Henry Co., Mass (c)
Permold Co., Ohio (a)
Pettibone Mulliken Corp., Ill (g)
Philadelphia Bronze & Brass Corp., Pa (a,b,f)
Pittsburgh Foundry & Machine Co., Pa (c)
Pittsburgh Steel Foundry Corp., Pa (g)
Pohlman Foundry Co., Inc., NY (c)
Portland Iron Works, Ore (c)
Posey Iron Works, Inc., Pa (c,g)
Potts, C. & G. Co., Ind (c)
Pratt, William E. Foundry Div., Joslyn Mfg. & Supply Co., Ill (c)
Prescott Co., Mich (a,c)
Pusey & Jones Corp., Del (c)
Quaker Alloy Casting Co., Pa (c,f,g)
Quality Aluminum Casting Co., Wis (a)
Quality Electric Steel Castings, Inc., Tex (g)
Quincy Steel Casting Co., Mass (g)
Racine Steel Castings Co., Belle City Malleable Iron Div., Wis (c)
Refinery Castings Co., Tex (g)
Reliance Foundry Co., Ohio (c)
Rensselaer Valve Co., NY (c)
Richmond Foundry & Mfg. Co., Inc., Va (a,b,c,d,f,j)
Ridge Foundry, Calif (c)
Riverside Foundry & Galvanizing Co., Mich (a,b,c,f)
Rockwell Engineering Co., Ill (a,b,c,g)
Rolle Mfg. Co., Pa (a,e)
Rosedale Foundry & Machine Co., Pa (c)
Ross-Meehan Foundries, Tenn (c,g)
Saginaw Bearing Co., Mich (a,b)
St. Louis Malleable Casting Co., Mo (c)
St. Louis Steel Casting, Inc., Mo (g)
St. Marys Foundry Co., Ohio (c)
Sall Bros. Co., Ill (a,b)
San Francisco Iron Foundry, Calif (a,c)
Sandy Hill Iron & Brass Works, NY (a,b,c)
Saran Lined Pipe Co., Div. of Michigan Pipe Co., Mich (c,g)
Sargent & Greenleaf, Inc., NY (a,b)
Savannah Machine & Foundry Co., Foundry Div., Ga (a,b,c,d)
Schaefer-Goodnow Foundries, Inc., Pa (c)
Schilling Bronze Co., NY (a,b,d,f,j)
Schmeller Aluminum Foundry Co., Ohio (a)
Schneider, Bowman Co., Inc., Pa (c)
Scottdale Ozone Co., Pa (a,c)
Scovill Mfg. Co., Mill Products Div., Conn (b)
Scudder, E. J. Foundry & Machine Co., NJ (f,g)
Scullin Steel Co., Mo (g)
Selma Foundry & Machine Co., Ala (c)
Sequoia Metalcraft Co., Inc., Calif (e)
Shakopee Foundry Co., Minn (c)
Shartle Div., Black-Clawson Co., Ohio (a,b,c)
Sheffield Foundry Co., Ill (c)
Sherman & Reilly, Inc., Tenn (a,c,g)
Shriver, T. & Co., Inc., NJ (a,b,c,d)
Sibley Machine & Foundry Corp., Ind (c)
Silcocks Miller Co., NJ (b,j)
Sinclair Co., Mass (a,b)
Sioux City Foundry & Boiler Co., Iowa (a,c)
Sivyer Steel Casting Co., Wis (g)
Smith, A.P. Mfg. Co., NJ (c)
Smith & Winchester Mfg. Co., Conn (a,b,c,g)
Solon Foundry, Inc., Ohio (a,b,e)
Somerset Foundry & Machine Co., Pa (a,c,d)
Sonith Foundries Div., Food Machinery & Chemical Corp., Ind (b,c)
Sorbo-Cast Corp., NJ (c)
Sorbo-Mat Process Engineers, Mo (c)
Southern Metal Products Co., La (a)
Sparta Foundry Div., Muskegon Piston Ring Co., Mich (c)
Spencer's, I.S. Sons, Inc., Conn (a,b,c)
Spring City Foundry Co., Pa (c)
Springer's Foundry Co., Inc., Ind (a,c)
Springfield Foundry Co., Mass (c)
Spuck Iron & Foundry Co., Mo (c)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Stainless Foundry & Engineering, Inc., Wis (f)
Standard Casting Corp., Ill (a,b,d)
Standard Foundry Co., Mass (c)
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa (g)
Star Heel Plate Co., Inc., NJ (c,g)
State Foundry & Machine Co., Wis (c)
Stearns-Roger Mfg. Co., Colo (c)
Sterling Brass Foundry, Inc., Ind (c)
Sterling Foundry Co., Inc., Ill (a, b,c)
Sterrit-Thomas Foundry Co., Pa (c)
Stillman White Foundry Co., Inc., RI (a,b,d)
Strong Steel Foundry Co., NY (g)
Stulz-Sickles Co., NJ (g)
Superb Light Alloys, Inc., NY (a,e)
Superior Foundry, Inc., Ohio (c,g)
Swayne-Robinson & Co., Ind (a,c)
Swedish Crucible Steel Co., Mich (g)
Swett, A.L. Iron Works, NY (c)
Taylor & Co., Inc., NY (c)
Taylor & Boggis Foundry, Ohio (c)
Taylor-Wharton Co., Div. of Harsco Corp., NJ (g)
Terre Haute Bronze & Brass Foundry, Inc (b)
Terre Haute Malleable & Mfg. Corp., Ind (c)
Texas Foundries, Inc., Tex (c,g)
Thys Co., Calif (g)
Tickle, Arthur Engineering Works, Inc., NY (a)
Tower Grove Foundry, Mo (c)
Trenton Brass Co., NJ (b)
True Alloys, Inc., Mich (a,b,d,j)
Turner & Seymour Mfg. Co., Conn (c)
Union Iron Works, Wash (c,g)
Unitcast Corp., Ohio
(g)—Ad p 467
U.S. Magnet & Alloy Corp., NJ (c, f,g)
U.S. Pipe and Foundry Co., Ala (c)
Uniworld Research Corp. of America, Ohio (c,f)
Utica General Jobbing Foundry, Inc., NY (c)
Utica Radiator Corp., NY (c)
Valley Iron Works, Inc., Minn (c)
Valley Steel Casting Co., Mich (g)
Viking Pump Co., Iowa (c)
Vollrath Co., Wis (a,b,g)
Vulcan Foundry Co., Calif (c)
Vulcan Rail & Construction Co., NY (a,c,g)
Wagner Malleable Iron Co., Ill (c)
Wall Colmonoy Corp., Stainless Process Div., Mich (c,f)
Waltham Foundry Co., Mass (a,c)
Washington Iron Works, Wash (c)
Waterman Industries, Inc., Calif (a, b,c)
Waukesha Foundry Co., Wis (a,b,f,g)
Wayne Agricultural Works, Inc., NC (b,c)
Wayne Foundry & Stamping Co., Mich (d,j)
Weber-Knapp Co., NY (a)
Webster Mfg. Inc., Ohio (c)
Wellman Bronze & Aluminum Co., Ohio (a,e)
Werner Foundry & Machine Co., Pa (c)
West Haven Foundry Co., Conn (a,b,d, f,j)
West Point Foundry & Machine Co., Div. of Batson-Cook Co., Ga (a,c,d)
West Steel Casting Co., Ohio (f,g)
Western Automatic Machine Screw Co., Ohio (c)
Western Foundry & Machine Works, Inc., Kan (c)
Western Iron & Foundry Co., Inc., Kan (c)
Westlectric Castings, Inc., Calif (g)
Westmoreland Malleable Iron Co., NY (c)
Williams, A.C. Co., Ohio (e)
Williams, E.A. & Son, NJ (a,b)
Winters Foundry & Machine Co., Inc., Ohio (a,b,d,f,j)
Wisconsin Aluminum Foundry Co., Inc., Wis (a,b)
Wollaston Foundry Corp., Mass (c)
Woodruff & Edwards, Inc., Ill (c)
Worthington Corp., NJ (c)
Zenith Foundry Co., Wis (c)

Castings, Shell Mold

Abco Aluminum & Brass Works, Tex (a,b,d,f,j)
Aelco Foundries, Inc., Wis (a,b,f,g)
Albion Malleable Iron Co., Mich (c)
Alloy Precision Castings Co., Ohio (a, b,c,e,f,g)
Alloy Steel Casting Co., Pa (f,g)
Almont Mfg. Co., Mich (c)
American Aluminum Casting Co., NJ (a)
American Cast Iron Pipe Co., Ala (c)
American Manganese Steel Div., American Brake Shoe Co., Ill (g)
American Steel Foundries, Ill (g)
Ampco Metal, Inc., Wis (b)
Arwood Corp., NY (a,b,e,g)
Atlas Foundry & Mfg. Co., Calif (a,b, c,g)
Aurora Metal Co., Ill (b)
Austenal Co., Div. of Howe Sound Co., NY (a,c,f,g)
Auto Specialties Mfg. Co., Mich (g)
Baxter Foundry & Machine Works, Inc., Ind (c)
Bendix Foundries Div., Bendix Aviation Corp., NJ (a,e)
Bethlehem Steel Co., Pa (g)
Blaw-Knox Co., Pa (f,g)
Buckeye Brass & Mfg. Co., Ohio (a,b)
Cadillac Malleable Iron Co., Mich (c)
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich (c)
Castalloy Co., Inc., Mass (a,e)
Chicago Hardware Foundry Co., Ill (a, b,c)
Chicago Malleable Castings Co., Ill (c)
Cochrane Foundry, Inc., Pa (a,b,j)
Cooper Alloy Corp., NJ (g)
Crawford & Doherty Foundry Co., Ore (c)
Crobalt, Inc., Mich (g)
Crucible Steel Casting Co., Pa (g)
Curtiss-Wright Corp., Metals Processing Div., NY (f,g)
Dayton Malleable Iron Co., Ohio (c)
Dirilyte Co. of America, Inc., Ind. (b)
Dodge Steel Co., Pa (g)
Duraloy Co., Pa
(f)—Ad p 417
Eaton Mfg. Co., Foundry Div., Mich
(c)—Ad p 459
Eclipse-Pioneer Div., Bendix Aviation Corp., NJ (a,e)
Electric Steel Foundry Co., Ore (f,g)
Electro-Alloys Div., American Brake Shoe Co., Ohio (g)
Electron Corp., Colo (c)
Emmaus Foundry & Machine Co., Pa (a,b,c)
Empire Steel Castings, Inc., Pa (g)
Erie Casting Co., Pa (c)
Fischer Casting Co., Inc., NJ (a)
Forest City Foundries Co., Ohio (c)
Fort Pitt Steel Casting Div., Pittsburgh Steel Foundry Corp., Pa (f,g)
Foster Aluminum Alloy Products Corp., NY (a)
Gale Mfg. Co., Mich (c)
General Electric Co., Foundry Dept., NY (f,g)
General Motors Corp., Central Foundry Div., Mich (c)
General Motors Corp., Fabricast Div., Ind (a)
Gilbert Brass Foundry Co., Mo (a,b)
Grimm Foundry Co., Inc., NJ (c)
Gunite Foundries Corp., Ill (c,g)
Haynes Stellite Co., Div. of Union Carbide Corp., Ind (f)
Hica, Inc., La (g)
Hobbs, Clinton E. Co., Mass (a,b,c)
Howard Foundry Co., Ill (a,b,c,e,f,g)
Investment Casting Co., NJ (a,b,c,f,g)
Ironton Malleable Div., Dayton Malleable Iron Co., Ohio (c)
Jamestown Malleable Iron Corp., NY (c)
Laconia Malleable Iron Corp., NH (c)
Lakeside Malleable Casting Co., Wis (c)
Lebanon Steel Foundry, Pa (g)
Lehigh, Inc., Pa (c)
Liberty Foundry Co., Mo (c,g)
Light Metals Dept., American Brake Shoe Co., NJ (a)
Link-Belt Co., Ill (c)
Loeffler, J.M. Co., Machine & Brass Works, Pa (b)
Lumen Bearing Co., NY (b)
Lynchburg Foundry Co., Castings Div., Va (c)
Mallory, P.R. & Co., Inc., Ind (b)
Marshall Car Wheel & Foundry Co., Inc., Tex (c)
Massillon Steel Casting Co., Ohio (g)
McCarter Iron Works, Inc., Pa (c,g)
Meehanite Metal Corp., NY
(c)—Ad p 461
Mercast Mfg. Corp., Calif (a,b,c,e,f,g)
Michigan Steel Casting Co., Div. of Consolidated Foundries & Mfg. Corp., Mich (g)
Midwest Foundry Co., Div. of L.A. Darling Co., Mich (c,g)
Misco Precision Casting Co., Mich (c,f, g)
Missouri Diecasting Co., Mo (a,b,c,g)
National Bearing Div., American Brake Shoe Co., Pa (b)
National Lead Construction Co., Inc., NJ (d)
National Malleable & Steel Castings Co., Ohio (c)
Northern Malleable Iron Co., Minn (c)
Ohio Steel Foundry Co., Ohio (f,g)
Oklahoma Steel Casting Div., American Steel & Pump Corp., Okla (g)
Olderman Mfg. Corp., Conn (j)
Olympic Steel Works, Wash (g)
Oregon Brass Works, Ore (a,b)
Oregon Metallurgical Corp., Ore (h)
Pacific Brass Foundry of San Francisco, Calif (a,b,f,j)
Parker, Charles Co., Conn (a,b)
Pelton Steel Casting Co., Wis (f,g)
Perfecto Cast, Calif (f,g)
Pettibone Mulliken Corp., Ill (g)
Pratt & Letchworth Div., Dayton Malleable Iron Co., Inc., NY (g)
Pusey & Jones Corp., Del (c)
Quaker Alloy Casting Co., Pa (c,f,g)
Ridge Foundry, Calif (c)
Rockwell Engineering Co., Ill (a,b,c,g)
Rolle Mfg. Corp., Pa (a,e)
Ross-Meehan Foundries, Tenn (c,g)
Sall Bros. Co., Ill (a,b)
Schilling Bronze Co., NY (a,b,d)
Sorbo-Mat Process Engineers, Mo (c)
Spencer's, I.S. Sons, Inc., Conn (c)
Star Heel Plate Co., Inc., NJ (a,b, c,g)
State Foundry & Machine Co., Wis (c)
Superb Light Alloys, Inc., NY (a,e)
Taylor & Co., Inc., NY (c)
Texas Foundries, Inc., Tex (c,g)
Trenton Brass Co., NJ (b)
True Alloys, Inc., Mich (a,b,d,j)
Unitcast Corp., Ohio
(g)—Ad p 467
U.S. Magnet & Alloy Corp., NJ (c,f,g)
Uniworld Research Corp. of America, Ohio (c,f)
Utica General Jobbing Foundry, Inc., NY (c)
Utility Steel Foundry, Calif (c,g)
Wall Colmonoy Corp., Stainless Process Div., Mich (c,f)
Waterman Industries, Inc., Calif (b,c)
Waukesha Foundry Co., Wis
(a,b,f,g)—Ad p 451
Wayne Agricultural Works, Inc., NC (b,c)
West Steel Casting Co., Ohio (f,g)
Western Automatic Machine Screw Co., Ohio (c)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (a,b,c,f,g,h)
Winters Foundry & Machine Co., Inc., Ohio (a,b,d,f,j)
Woodruff & Edwards, Inc., Ill (c)
Zenith Foundry Co., Wis (c)

Cellophane

(see Cellulose, Regenerated)

Cellulose Acetate

aaRBee Plastic Co., Calif (y)
Ace Plastic Co., NY (bb,cc,dd,ee)
Adhesive Products Corp., NY (z)
Albany Novelty Mfg. Co., Mass (t)
American Hard Rubber Co., Div. of Amerace Corp., NJ (bb,dd,ee)
American Products Mfg. Co., La (t)
Anchor Plastics Co., Inc., NY (bb, dd,ee)
Auburn Plastic Engineering, Ill (bb, cc)
Auburn Plastics, Inc., NY (bb,dd,ee)
Bamberger, Claude P., Inc., NJ (p,y)
Blank, Arthur & Co., Inc., Mass (t, cc)
Cadillac Plastic & Chemical Co., Mich (t,bb,cc,dd,ee)
Carroll, J.B. Co., Ill (cc)
Celanese Plastics Co., Div. of Celanese Corp. of America, NJ
(p,s,t,y,cc)—Ad pp 271-274
Celluplastic Corp., NJ (bb,ee)
Chemical Development Corp., Mass (p)
Chicago Molded Products Corp., Campco Div., Ill
(t,cc)—Ad p 243
Coating Products, Inc., NJ (t,cc)
Colonial Kolonite Co., Ill (t,bb,cc, dd,ee)
Comco Plastics, Inc., NY (cc,dd)
Commercial Plastics & Supply Corp., NY (bb,cc,ee)
Cosmos Plastics Co., Ohio (u)
Craftint Mfg. Co., Ohio (cc)
Crane Plastics, Inc., Ohio (bb,dd,ee)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Curbell, Inc., NY (cc)
Davis, Joseph Plastics Co., NJ (t, y,bb,cc,dd,ee)
Denver Plastics, Inc., Colo (u)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
du Pont de Nemours, E.I. & Co., Inc., Del (p,s,cc)
Dura Plastics of New York, Inc., NY (cc)
Dyna-Therm Chemical Corp., Calif (p)
Eastman Chemical Products, Inc., Sub. of Eastman Kodak Co., NY (p,y)
Eastman Kodak Co., NY (t,cc)
Eljay Corp., Md (cc)
Fry Plastics International, Calif (t,cc)
General Gasket, Inc., Conn (t,cc)
General Plastics Mfg. Co., Wash (bb,cc,dd,ee)
Gering Plastics, Div. of Studebaker-Packard Corp., NJ (y)
Glass Laboratories, NY (bb,dd,ee)
Gomar Mfg. Co., Inc., NJ (cc)
Hastings & Co., Inc., Pa (t)
Heyden Newport Chemical Corp. American Plastics Corp. Div., NY (bb,cc,dd,ee)
Industrial Plastics Corp., Ind (bb,dd
Insulation Mfrs. Corp., Ill (t,cc,dd
Jet Specialties Co., Inc., Calif (bb cc,dd,ee)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Knoedler Chemical Co., Pa (bb,cc
Luminous Resins, Inc., Ill (y)
Lus-Trus Corp., Mich (cc,ee)
Midwest Plastic Products Co., Ill (t,cc)
Monsanto Chemical Co., Plastics Div., Mass (t)
Muehlstein, H. & Co., Inc., NY (y)
National Gasket & Washer Mfg. Co., Inc., NY (cc,dd)
New England Tape Co., Div. of United-Carr Fastener Corp., Mass (bb,cc)
Nixon Nitration Works, NJ (bb,cc,ee)
Norrich Plastics Corp., NY (bb,cc,ee)
Omni Products Corp., NY (y,bb,cc)
Ormond Mfg. Co., Inc., NJ (cc,dd)
Pacific Coast Foil Co., Calif (t)
Panelyte Div., St. Regis Paper Co., NJ (cc)

Suppliers of Materials

Perfex Plastics, Inc., (bb,dd,ee)
Philrus Products Co., NJ (cc,dd)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (x)
Plast-Ad Mfg. Co., Ind (cc)
Plastic Compounding Corp., Sub. of Plastiglide Mfg. Corp., Calif (y)
Plastic Materials, Inc., NY (y)
Precision Paper Tube Co., Ill (ee)
Pyramid Plastics, Inc., Ill (dd,ee)
Reed Plastics Corp., Mass (y)
Rosco Laboratories, NY (cc)
Rowland Products, Inc., Conn (x,bb, cc,dd,ee)
Russell Mfg. Co., Conn (s)
Schwab Plastic Corp., Mich (u,bb,cc, dd,ee)
Scranton Plastic Laminating Corp., Pa (cc)
Simon Products Co., Ill (t,cc)
Snyder Mfg. Co., Inc., Ohio (t,cc)
Southern Plastics Co., SC (bb,cc,dd, ee)
Stone Paper Tube Div., Stone Straw Corp., Washington, DC (ee)
Sunlites Plastics, Inc., Wis (bb,dd,ee)
Superior Plastics, Inc., Ill (bb,cc,dd, ee)
Western Felt Works, Ill (cc)
Westlake Plastics Co., Pa (bb,cc,dd, ee)
World Plastics, NY (bb,cc,dd,ee)

Cellulose Acetate Butyrate

aaRBee Plastic Co., Calif (y)
Ace Plastic Co., NY (bb,cc,dd,ee)
Adhesive Products Corp., NY (x)
Albany Novelty Mfg. Co., Mass (t,cc)
American Hard Rubber Co., Div. of Amerace Corp., NJ (bb,dd,ee)
American Molding Powder & Chemical Co., NY (y)
Anchor Plastics Co., Inc., NY (bb,dd, ee)
Anderson Assoc., Inc., Ohio (y)
Anesite Co., Ill (ee)
Auburn Plastic Engineering, Ill (t,bb, cc,ee)
Auburn Plastics, Inc., NY (bb,cc, dd,ee)
Bamberger, Claude P., Inc., NJ (p,y)
Bischoff Chemical Corp., NY (u)
Blank, Arthur & Co., Inc., Mass (t,cc)
Busada Mfg. Corp., NY (ee)
Cadillac Plastic & Chemical Co., Mich (bb,cc,dd,ee)
Carroll, J.B. Co., Ill (cc)
Celluplastic Corp., NJ (bb,ee)
Chicago Molded Products Corp., Campco Div., Ill (t,cc)
Coating Products, Inc., NJ (t,cc)
Colonial Kolonite Co., Ill (t,bb,cc,ee)
Columbus Coated Fabrics Corp., Ohio (u)
Comco Plastics, Inc., NY (cc,dd,ee)
Commercial Plastics & Supply Corp., NY (bb,cc,ee)
Cosmos Plastics Co., Ohio (u)
Crane Plastics, Inc., Ohio (bb,dd,ee)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Davis, Joseph Plastics Co., NJ (t,y, bb,cc,dd,ee)
Denver Plastics, Inc., Colo (u)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
Durable Form Products, Inc., NY (cc, ee)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y)
Eastman Chemical Products, Inc., Sub. of Eastman Kodak Co., NY (p,y)
Eastman Kodak Co., NY (t,cc)
Fidelity Chemical Products Corp., NJ (u)
Fry Plastics International, Calif (t,cc)
General Gasket, Inc., Conn (t,cc)
General Plastics Corp., Ind (cc)
General Plastics Mfg. Co., Wash (bb, cc,dd,ee)
Gering Plastics, Div. of Studebaker-Packard Corp., NJ (y)
Glass Laboratories, NY (bb,dd,ee)
Gomar Mfg. Co., Inc., NJ (cc)
Grigoleit Co., Ill (p,s)
Heyden Newport Chemical Corp., American Plastics Div., NY (bb,cc, dd,ee)
Hydrawlik Co., NJ (bb,dd)
Industrial Plastics Corp., Ind (bb,dd)
Jet Specialties Co., Inc., Calif (bb, cc,dd,ee)
K S H Plastics, Inc., Mo (bb,cc,dd)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Luminous Resins, Inc., Ill (y)
Lus-Trus Corp., Mich (cc,ee)
Midwest Plastic Products Co., Ill (t, cc)
Muehlstein, H & Co., Inc., NY (y)
New England Tape Co., Div. of United-Carr Fastener Corp., Mass (bb,cc)
Nixon Nitration Works, NJ (bb,cc,ee)
Omni Products Corp., NY (y,bb,cc)
Panelyte Div., St. Regis Paper Co., NJ (cc)
Perfex Plastics, Inc., Ill (bb,dd,ee)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (x)
Plastic Compounding Corp., Sub. of Plastiglide Mfg. Corp., Calif (y)
Polymer Corp., Pa (y)
Precision Paper Tube Co., Ill (ee)
Pyramid Plastics, Inc., Ill (dd,ee)
Rowland Products, Inc., Conn (x,bb,cc, dd,ee)
Schwab Plastic Corp., Mich (u,bb,cc, dd,ee)
Scranton Plastic Laminating Corp., Pa (cc)
Shoe Form Co., Inc., De Witt Plastics Div., NY (cc,dd,ee)
Snyder Mfg. Co., Inc., Ohio (t,cc)
Southern Plastics Co., SC (bb,cc,dd, ee)
Sunlites Plastics, Inc., Wis (bb,dd, ee)
Superior Plastics, Inc., Ill (bb,cc, dd,ee)
Western Felt Works, Ill (cc)
Western Plastics Corp., Neb (bb, dd,ee)
Westlake Plastics Co., Pa (bb,cc,dd, ee)
World Plastics, NY (bb,cc,dd,ee)

Cellulose Nitrate

Adhesive Products Corp., NY (x)
Chemical Development Corp., Mass (p)
Columbus Coated Fabrics Corp., Ohio (u)
Crescent Plastics, Inc., Ind (ee)
du Pont de Nemours, E.I. & Co., Inc., Del (p)
General Gasket, Inc., Conn (t)
Hercules Powder Co., Inc., Del (p)
Kaufman Glass Co., Del (cc)
Nixon Nitration Works, NJ (bb,cc,ee)
Omni Products Corp., NY (bb,cc)
Panelyte Div., St. Regis Paper Co., NJ (cc)
Rowland Products, Inc., Conn (x,cc)
Wasco Products, Inc., Mass (cc)
Western Felt Works, Ill (cc)

Cellulose Propionate

aaRBee Plastic Co., Calif (y)
Adhesive Products Corp., NY (x)
American Hard Rubber Co., Div. of Amerace Corp., NJ (bb,ee)
Anchor Plastics Co., Inc., NY (bb,dd, ee)
Anderson Assoc., Inc., Ohio (y)
Celanese Plastics Co., Div. of Celanese Corp. of America, NJ (p,y)—Ad pp 271-274
Eastman Chemical Products, Inc., Sub. of Eastman Kodak Co., NY (y)
Glass Laboratories Inc., NY (bb,dd,ee)
Panelyte Div., St. Regis Paper Co., NJ (cc)
Perfex Plastic, Inc., Ill (bb,dd)
Southern Plastics Co., SC (bb,cc,dd,ee)
Superior Plastics, Inc., Ill (ee)
World Plastics, NY (bb,cc,dd,ee)

Cellulose, Regenerated

(e.g., Cellophane)
Adhesive Products Corp., NY (x)
American Viscose Corp., Pa (s,t)—Ad p 313
Blank, Arthur & Co., Inc., Mass (t)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
du Pont de Nemours, E.I. & Co., Inc., Del (s,t,cc)
Foss Mfg. Co., Id (t)
Kaufman Glass Co., Del (cc)
Mason Envelope Co., Inc., NY (t)
Olin Mathieson Chemical Corp., Packaging Div., NY (t)
Pacific Coast Foil Co., Calif (t)

Cemented Carbides

(see Cermets)

Centrifugal Castings

(see Castings)

Ceramic Coatings

(see Inorganic Coatings)

Ceramics, Alumina

Alite Div., U.S. Stoneware Co., Ohio (r)
American Lava Corp., Tenn (r,z,bb,ee)
Brunswick Corp., Va (r,u)
CFI Corp., NY (r,bb,ee)
Carborundum Co., NY (r,z,aa,bb,ee)
Carborundum Co., Refractories Div., NJ (r,s,z,aa,bb,cc,ee)
Centralab Div., Globe Union, Inc., Wis (r,bb,cc)—Ad p 449
Continental Coatings Corp., Ohio (aa)
Coors Porcelain Co., Colo (r,bb,ee)
Corning Glass Works, NY (r)
Diamonite Products Mfg. Co., Ohio (r,z,bb,cc,ee)
Du-Co Ceramics Co., Pa (r,bb,ee)
Electric Autolite Co., Ceramic Div., Ohio (r,u,z,bb,ee)
Electro Refractories & Abrasives Corp., NY (r)
Engineered Ceramics Mfg. Co., Ill (r, z,bb,ee)
Frenchtown Porcelain Co., NJ (r,bb, cc,ee)
Gladding, McBean & Co., Technical Ceramic Div., Calif (r,u,z,bb,cc,ee)
Gulton Industries, Inc., NJ (r,aa,bb,ee)
Louthan Mfg. Div., Ferro Corp., Ohio (z)
Mansol Ceramics Co., NJ (r)
McDanel Refractory Porcelain Co., Pa (r,bb,cc,ee)—Ad p 308
Metallizing Engineering Co., Inc., NY (aa)
Metallizing Co. of Los Angeles, Inc., Calif (r,bb)
Monsanto Chemical Co., Inorganic Chemicals Div., Mo (aa)
Morganite Inc., NY (r,z,aa,bb,ee)
National Beryllia Corp., NJ (r,z,bb, cc,ee)
Norton Co., Mass (r,z,aa,bb,ee)
Pyrosil, Inc., Ohio (r)
Saxonburg Ceramics, Inc., Pa (r,z,bb, cc,ee)
U.S. Stoneware Co., Ohio (r)
Western Gold & Platinum Co., Sub. of Wilbur B. Driver Co., Calif (r, z,aa,bb,cc,ee)
Zirconium Corp. of America, Ohio (r, z,bb,ee)

Ceramics, Corundum

Carborundum Co., NY (r,z,bb,ee)
Electrical Refractories Co., Ohio (r)
Engineered Ceramics Mfg. Co., Ill (r, z,bb,ee)
Metallizing Engineering Co., Inc., NY (aa)
Morganite Inc., NY (r,z,bb,ee)

Ceramics, Forsterite

American Lava Corp., Tenn (r,z,bb,ee)
CFI Corp., NY (r,bb,ee)
Corning Glass Works, NY (r)
Du-Co Ceramics Co., Pa (r,bb,ee)
General Ceramics Div., Indiana General Corp., NJ (r, bb, ee)

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e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

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s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Gladding, McBean & Co., Technical Ceramic Div., Calif (r,z,bb,cc,ee)
Saxonburg Ceramics, Inc., Pa (r,z,bb, ee)

Ceramics, Rare Earth

Continental Coatings Corp., Ohio (aa)
Electric Autolite Co., Ohio (r)
Engineered Ceramics Mfg. Co., Ill (r, z,bb,ee)
Metallizing Engineering Co., Inc., NY (aa)
National Beryllia Corp., NJ (r,z,bb, cc,ee)
Nuclear Metals, Inc., Mass (r)
Research Chemicals Div., Nuclear Corp. of America, Calif (aa,bb)
Zirconium Corp. of America, Ohio (r, z,aa,bb,ee)

Ceramics, Steatite

American Lava Corp., Tenn (r,z,bb,ee)
CFI Corp., NY (r,bb,ee)
Carborundum Co., NY (r,z,bb,ee)
Carborundum Co., Refractories Div., NJ (r,z,bb,ee)
Centralab Div., Globe Union, Inc., Wis
(r,bb,cc)—Ad p 449
Du-Co Ceramics Co., Pa (r,bb,ee)
Gladding, McBean & Co., Technical Ceramic Div., Calif (r,z,bb,cc,ee)
Louthan Mfg. Div., Ferro Corp., Ohio (r,ee)
Mansol Ceramics Co., NJ (r)
Saxonburg Ceramics, Inc., Pa (r,z,bb, ee)
Star Porcelain Co., NJ (r,z,bb,cc,ee)
Steward, D. M. Mfg. Co., Tenn (r,z, bb,ee)
Wisconsin Porcelain Co., Wis (r,bb, cc,ee)

Ceramics, Whiteware

American Lava Corp., Tenn (r,z,bb,ee)
Carborundum Co., NY (r,z,bb,ee)
Du-Co Ceramics Co., Pa (r,bb,ee)
Frenchtown Porcelain Co., NJ (r,bb, cc,ee)
General Ceramics Div., Indiana General Corp., NJ (r, bb, ee)
Gladding, McBean & Co., Technical Ceramic Div., Calif (r,z,bb,cc,ee)
Knight, Maurice A. Co., Ohio (r,ee)
Saxonburg Ceramics, Inc., Pa (r,z, bb,ee)
Star Porcelain Co., NJ (r,z,bb,cc,ee)
Steward, D. M. Mfg. Co., Tenn (r, z,bb,ee)
Wisconsin Porcelain Co., Wis (r,bb, cc,ee)

Ceramics, Other

Akron Porcelain Co., Ohio (r)
American Lava Corp., Tenn (r,z,bb,ee)
Amersil Quartz Div., Engelhard Industries, Inc., NJ
(r,s,z,aa,bb,cc,ee)—Ad p 159
Arnold Engineering Co., Ill (r)
Beryl Ores Co., Colo (aa,cc)
Brunswick Corp., Va (r,u)
Brush Beryllium Co., Ohio (r,z,aa,bb, ee)
Carborundum Co., NY (r,s,u,z,aa,bb, ee)
Carborundum Co., Refractories Div., NJ (r,z,aa,bb,cc,ee)
Centralab Div., Globe Union, Inc., Wis
(r,bb,cc)—Ad p 449
Continental Coatings Corp., Ohio (aa)
Coors Porcelain Co., Colo (r,bb,ee)
Corning Glass Works, NY (r)
Electric Autolite Co., Ohio (r)
Electrical Refractories Co., Ohio (r, ee)
Electro Refractories & Abrasives Corp., NY (r)
Emerson & Cuming, Inc., Mass (u, aa,cc)
Engineered Ceramics Mfg. Co., Ill (r, z,bb,ee)
Ferroxcube Corp. of America, NY (r, bb)
Frenchtown Porcelain Co., NJ (r,bb, cc,ee)
Gladding, McBean & Co., Technical Ceramic Div., Calif (r,z,bb,cc,ee)
Gulton Industries, Inc., NJ (aa)
Knight, Maurice A. Co., Ohio (r,ee)
Laboratory Equipment Corp., Mich (r, z,bb,cc,ee)
Louthan Mfg. Div., Ferro Corp., Ohio (r,z,bb,ee)
Malvern Brick & Tile Co., Ark (r)
Mansol Ceramics Co., NJ (r)
McDanel Refractory Porcelain Co., Pa
(r,bb,cc,ee)—Ad p 308
Metal & Thermit Corp., NJ (aa)
Metallizing Engineering Co., Inc., NY (aa)
Metallizing Co. of Los Angeles, Inc., Calif (r,bb)
Monsanto Chemical Co., Inorganic Chemicals Div., Mo (aa)
Mycalex Corp. of America, NJ (r,z,aa, bb,cc,ee)
National Beryllia Corp., NJ (r,z,bb, cc,ee)
Nuclear Metals, Inc., Mass (r)
Pyrosil, Inc., Ohio (r,z,aa,bb,cc,ee)
Saxonburg Ceramics, Inc., Pa (r,z,bb, ee)
Star Porcelain Co., NJ (r,z,bb,cc,ee)
Steward, D. M. Mfg. Co., Tenn (r,z, bb,ee)
Taunton Div., Haveg Industries, Inc., Mass (r)
U.S. Stoneware Co., Ohio (r)
Wisconsin Porcelain Co., Wis (r,bb, cc,ee)
Zirconium Corp. of America, Ohio (r, z,aa,bb,ee)

Cermets

Aerojet-General Corp., Structural Materials Div., Calif (r)
Allegheny Ludlum Steel Corp., Pa (r)
American Brakeblok Div., American Brake Shoe Co., Mich (r)
American Lava Corp., Tenn (r,z,bb,ee)
American Sinteel Corp., NY (r)
Brush Beryllium Co., Ohio (r,aa)
Carborundum Co., NY (r)
Climax Molybdenum Div., American Metal Climax, Inc., NY (r)
Continental Coatings Corp., Ohio (aa)
Emerson & Cuming, Inc., Mass (r,u)
Firth Sterling, Inc., Pa (r)
General Electric Co., Metallurgical Products Dept., Mich (r)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (r, u,aa)
Haynes Stellite Co., Div. of Union Carbide Corp., Ind (r)
Hommel, O. Co., Pa (aa)
Industrial Tectonics, Inc., Mich (r)
Kanthal Corp., Conn (bb)
Kennametal, Inc., Pa
(r,aa,bb,ee)—Ad p 306
Metal Carbides Corp., Ohio (r)
Metal Hydrides, Inc., Mass (aa)
Metallizing Engineering Co., Inc., NY (aa)
Metallizing Co. of Los Angeles, Inc., Calif (bb)
Nuclear Metals, Inc., Mass (r,bb,cc, ee)
St. Eloi Corp., Ohio (r,z,aa)
Sintercast Div., Chromalloy Corp., NY (r)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (r,aa)
U.S. Stoneware Co., Ohio (r)

Chemical Conversion Coatings

(see Conversion Coatings)

Chlorinated Polyether

Hercules Powder Co., Inc., Del (y)
National Vulcanized Fibre Co., Del (bb,cc,ee)
Toyad Corp., Pa (u)

Chloroprene Rubber

(Neoprene)

Adhesive Products Corp., NY (x)
American Rubber Products Corp., Ind (u,bb,cc,dd,ee)
Atlas Mineral Products Co., Pa (c)
Auburn Rubber Co., Inc., Ind (cc)
Automotive Rubber Co., Inc., Mich (cc, dd)
Belko Corp., Md (y)
Bond International, Inc., Mich (y,ee)
Brown Rubber Co., Inc., Ind (u)
Capac Mfg. Corp., Mich (y,cc)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chemical Coatings & Engineering Co., Inc., Pa (x,y)
Chicago Rubber Co., Inc., Ill (u,y)
Colonial Rubber Co., Div. of U.S. Stoneware Co., Ohio
(y,cc,dd)—Ad p 441
Continental Rubber Works, Pa (bb,cc, dd,ee)
Coyne & Paddock, Inc., NY (cc)
Dayton Rubber Co., Ohio (y,bb,cc, dd,ee)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
du Pont de Nemours, E. I. & Co., Inc., Del
(p)—Ad p 231
Dutch Brand Div., Johns-Manville Corp., Ill (u,y,cc,dd)
Dyna-Therm Chemical Corp., Calif (p)
Electro Chemical Engineering & Mfg. Co., Pa (t,cc)
Faultless Rubber Co., Ohio (u,y,bb, ee)
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass (s,u,y,cc,ee)
Flexfirm Products, Calif (s)
Flexible Tubing Corp., Conn (ee)
Foamade Industries, Mich (u)
Garlock Packing Co., NY (y,bb,cc,dd, ee)
Geauga Industries Co., Ohio (y,bb,dd)
Goodrich, B.F. Co., Conn (u)
Goshen Rubber Co., Inc., Ind (y)
Hewitt-Robins, Inc., Conn (cc,ee)
Home Rubber Co., NJ (y,bb,cc,dd,ee)
Knight, Maurice A., Ohio (cc)
Maloney, F.H. Co., Tex (y)
Martin Rubber Co., Inc., NJ (y,dd,ee)
Mid-States Rubber Products, Inc., Ind (y)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (y)
Paeco Rubber Co., Inc., Ohio (y,dd, ee)
Parker Seal Co., Div. of Parker-Hannifin Corp., Calif (u)
Parker, Stearns & Co., Inc., NY (y, bb,cc,dd,ee)
Pawling Rubber Corp., NY (bb,dd,ee)
Polymer Chemical Co., Ohio (x)
Prince Rubber & Plastics Co., Inc., NY (bb,cc,ee)
Raybestos-Manhattan, Inc., Plastics Products Div., Pa (x)
Republic Rubber Div., Lee Rubber & Tire Corp., Ohio (p,y,cc,dd,ee)
Roberts Toledo Rubber Co., Ohio (ee)
Rogers Corp., Conn (u,y,cc,dd)
Roth Rubber Co., Ill (y,cc)
Rubatex Div., Great American Industries, Inc., Va (u)
Russell Mfg. Co., Conn (r,ee)
Sheller Mfg. Corp., Mich (u)
Snyder, M.L. & Son, Inc., Pa (cc,ee)
Standard Products Co., Mich (y)
Stockwell Rubber Co., Inc., Pa (u,y, bb,cc,dd)
Technical Specialties Co., NY (dd)
Toyad Corp., Pa
(u)—Ad p 260
Trostel, Albert Packing Ltd., Wis (y)
U.S. Rubber Co., Kem-Blo Dept., Conn
(u)—Ad p 250
U.S. Stoneware Co., Ohio (y)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (p,y,cc)
Vulcanized Rubber & Plastics Co., Pa (y)
Western Felt Works, Ill (y,cc,dd,ee)
Williams-Bowman Rubber Co., Ill (y, bb,cc,dd,ee)

Chlorosulfonated Polyethylene Rubber

Adhesive Products Corp., NY (x)
Atlas Mineral Products Co., Pa (cc)
Automotive Rubber Co., Inc., Mich (cc,dd)
Belko Corp., Md (y)
Bond International, Inc., Mich (y,ee)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chemical Coatings & Engineering Co., Inc., Pa (x,y)
Chicago-Allis Mfg. Corp., Ill (p)
Continental Rubber Works, Pa (bb,cc, dd,ee)
Dayton Rubber Co., Ohio (y,bb,cc,dd, ee)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
du Pont de Nemours, E. I. & Co., Inc., Del (p)
Electro Chemical Engineering & Mfg. Co., Pa (t,cc)
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass (y,cc,ee)
Flexfirm Products, Calif (s)
Hewitt-Robins, Inc., Conn (cc,ee)
Home Rubber Co., NJ (y,bb,cc,dd,ee)
Maloney, F.H. Co., Tex (y)
Paeco Rubber Co., Inc., Ohio (y,dd,ee)
Parker Seal Co., Div. of Parker-Hannifin Corp., Calif (u)
Plas-Kem Corp., Div. of Dyna-Therm Corp , Calif (x)
Prince Rubber & Plastics Co., Inc., NY (cc,ee)
Republic Rubber Div., Lee Rubber & Tire Corp., Ohio (p)
Roberts Toledo Rubber Co., Ohio (ee)
Rogers Corp., Conn (cc,dd)
Stockwell Rubber Co., Inc., Pa (cc)
Swan Rubber Co., Ohio (ee)
Toyad Corp., Pa
(t,u)—Ad p 260
Trostel, Albert Packing, Ltd., Wis (y)
Vulcan Rubber Products Div., Reeves Bros., Inc, NY (p,y,cc)
Western Felt Works, Ill (y,cc,dd,ee)
Williams-Bowman Rubber Co., Ill (y,bb,cc,dd,ee)

Chlorotrifluoroethylene

(see Fluorocarbon)

Chromate Coatings

(see Conversion Coatings)

Chromium

Alloy Metal Powder, Inc., Iowa (aa)
Alloy Metal Products, Inc., Iowa (o,w)
American Nickel Alloy Mfg. Corp., NY (w,aa)
Arcos Corp., Pa (ff)
Belmont Smelting & Refining Works, Inc., NY (w,aa)
Chicago Development Corp., Md (aa)
Foote Mineral Co., Pa (aa)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (aa)
Hull, R.O. & Co., Inc., Ohio (n)
K. & L. Plating Co., Pa (z)

Kawecki Chemical Co., NY (aa)
Lakeland Industries, Minn (z)
Metal Hydrides, Inc., Mass (aa)
Metal & Thermit Corp., NJ (w)
Metals Disintegrating Co., Inc., NJ (aa)
Michigan Seamless Tube Co., Mich (ee)
Modern Plating Corp., Ill (n)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Nuclear Metals, Inc., Mass (w,hh,dd, ee)
Republic Steel Corp., Steel & Tubes Div., Ohio (ee)
Sel-Rex Corp., NJ
(n)—Ad p 356
Shieldalloy Corp., NJ (aa)
Stevens, Frederic B., Inc., Mich (n)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY
(w,aa)—Ad p 181
Vanadium Corp. of America, NY (w)
Waimet Alloys Co., Mich
(w)—Ad p 82

Chromized Coatings

(see Diffusion Coatings)

Clad Metals

(key letters refer to base metals; see also Laminates, Metal-Metal)

Alabama Wire Co., Inc., Ala (a)
Al-Fin Div., Arthur Tickle Engineering Works, Inc., NY (a,e)
Allegheny Ludlum Steel Corp., Pa (g)
Aluminum Co. of America, Pa (a)
American Silver Co., NY (b,c,f,g)
Arrow Metal Products Corp., NJ (a)
Bart Mfg. Corp., NJ (a,b,c,e,f,g,h)
Bartlett-Thompson Co., Inc., Mass (a, b,f)
Bishop, J. & Co. Platinum Works, Pa (f,g)
Borg-Warner Corp., Ill (g)
Bridgeport Brass Co., Conn (b,f,g)
Chicago Bridge & Iron Co., Ill (g)
Chicago Development Corp., Md (h)
Clad-Rex Corp., Ill (a,g)
Composite Industrial Metals, Inc., RI (a,b,c,d,e,f,g,h,j)
Copper & Brass Sales, Inc., Mich (a)
Darby Corp., Kan (a,f,g)
Delco Moraine Div., General Motors Corp., Ohio (a,d)
Driver-Harris Co., NJ (f)
Electric Materials Co., Pa (c)
Electric Steel Foundry Co., Ore (f,g)
Electronic Parts Mfg. Co., Inc., NJ (b,f)
Enamel Products Co., Ohio (a,g)
Fromson Orban Co., Inc., NY (b,f,g)
General Alloys Co., Mass (f,g)
General Finding & Supply Co., Industrial Div., Mass (b)
Horton-Angell Co., Mass (b,f)
Improved Seamless Wire Co., RI (b,f)
Jessop Steel Co., Pa (g)
Johnson Bronze, Pa (a,b,d,g)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Kassel Export Co., Inc., NJ (b,c,g)
Kewaunee Engineering Corp., Wis (c)
Knapp Mills Inc., NY (a,b,d,g)
Leach & Garner Co., Industrial Div., Mass (b,f)
Lukens Steel Co., Pa (a,b,e,f,g,h)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (b,c,f,g)
Manufacturers & Fabricators, Inc., Ohio (f,g)
Metal Goods Corp., Mo (f)
National Galvanizing Co., Pa (g)
National Lead Co., NY (d)
National Lead Construction Co., Inc., NJ (d)
Nuclear Metals, Inc., Mass (a,b,c,e, f,g,h)
Olin Mathieson Chemical Corp., Metals Div., NY (a)
Parish Pressed Steel Div., Dana Corp., Pa (a,g,j)
Presswork, Inc., Mich (b,d)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY (b)
Reynolds Metals Co., Va (a)
Riverside-Alloy Metal Div., H.K. Porter Co., Inc., NJ (b,f)
Rockwell Engineering Co., Ill (a,b, c,g)
Saginaw Bearing Co., Mich (b,g)
Sandy Hill Iron & Brass Works, NY (g)
Seattle Boiler Works, Inc., Wash (g)
Sharpsville Steel Fabricators, Inc., Pa (g)
Sheldon, M.L. & Co., Inc., NY (f)
Somers Brass Co., Inc., Conn (f)
Standard Metals Corp., Mass (a,b,c, f,g)
Sun Steel Co., Ill (a,e,g)
Superior Steel Div., Copperweld Steel Co., Pa (g)
Sylvania Electric Products, Inc., Parts Div., Pa (b,g)
Texas Instruments, Inc., Metals & Controls Div., Mass
(a,b,c,f,g,h)—Ad p 465
Werner, R.D. Co., Pa (a,g)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (f,g,h)
Whitehead Metal Products Co., Inc., NY (f)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (f,g)
Worcester Wire Works Div., National-Standard Co., Mass (g)

Claddings

(see Organic Coatings; Clad Metals)

Coated Metals

(see Precoated Metals)

Coatings

(see specific type)

Cobalt and Its Alloys

African Metals Corp., NY (aa)
Alloy Metal Products, Inc., Iowa (o, w)
American Nickel Alloy Mfg. Corp., NY (w,aa)
Austenal Co., Div. of Howe Sound Co., NY (w)
Belmont Smelting & Refining Works Inc., NY (n,w,aa)
Cannon-Muskegon Corp., Mich (w)
Crucible Steel Co. of America, Titanium & Vacuum Metals Product Div., Pa (o,q,w,z,cc,dd)
Driver, Wilbur B. Co., NJ
(v,bb,dd,ff)—Ad p 185
Driver-Harris Co., NJ (bb,dd)
Dudek & Bock Spring Mfg. Co., Ill (ff)
Elgin National Watch Co., Abrasives Div., Ill (o,bb,dd,ff)
Foote Mineral Co., Pa (aa)
General Electric Co., Metallurgical Products Dept., Mich (q,w,aa,bb,cc, dd)
Hamilton Watch Co., Precision Metals Div., Pa (v,w,bb,cc,dd)
Hardy, Charles, Inc., NY (aa)
Haynes Stellite Co., Div. of Union Carbide Corp., Ind (o,q,v,w,z,bb,cc, dd,ee,ff)
Hoskins Mfg. Co., Mich
(bb,dd)—Ad p 177
K. & L. Plating Co., Pa (z)
Kelsey-Hayes Co., Metals Div., NY (o,q,v,w,z,bb,cc,dd,ff)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (o)
McGean Chemical Co., Ohio (aa)
Metal Hydrides, Inc., Mass (aa)
Michigan Seamless Tube Co., Mich (ee)
New Jersey Metals Co., NJ (w)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Nuclear Metals, Inc. Mass (w)
Sierra Metals Corp., Sub. of American-Marietta Co., Ill (w)
Stauffer-Temescal Co., Calif (o,q,w,z, bb,cc,dd,ee,ff)
Texas Instruments, Inc., Metals & Controls Div., Mass (v,dd)
Trent Tube Co., Sub. of Crucible Steel Co. of America, Pa (ee)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
Vanadium-Alloys Steel Co., Pa (aa)
Waimet Alloys Co., Mich
(w)—Ad p 82
Wall Colmonoy Corp., Stainless Process Div., Mich (w,bb)
Wallingford Steel Co., Conn (dd,ee)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb,cc,dd, ee)

Cold Extrusions

(see Impact Extrusions)

Cold Headed Parts

Abbott Ball Co., Conn (b,g)
Acme Machine Products Div., Serrick Corp., Ind (g)
Albany Products Co., Inc., Conn (b,f)
Allied Products Corp., Mich (g)
Allmetal Screw Products Co., Inc., NY (f,g,h)
Aluminum Co. of America, Pa (a)
American Car & Foundry Div., ACF Industries, Inc., NY (g)
Ampco Metal, Inc., Wis (b)
Anti-Corrosive Metal Products Co., Inc., NY (g)
Armco Steel Corp., Sheffield Div., Mo (g)
Art Wire & Stamping Co., NJ (a,b,c, d,f,g)
Bead Chain Mfg. Co., Conn (a,g)
Bethlehem Steel Co., Pa (g)
Camcar Screw & Mfg. Co., Ill (a,g,h)
Central Screw Co., Ill (a,b,c,f,g)
Champion Rivet Co., Ohio (c,g)
Chandler Products Corp., Ohio (g)
Chicago Rivet & Machine Co., Ill (a, c,g)
Chicago Screw Co., Div. of Standard Screw Co., Ill (a,b,c,f,g)
Clark Bros. Bolt Co., Conn (a,b,c,g)
Clendenin Bros., Inc., Md (a,b,c)
Cleveland Cap Screw Co., Ohio (a, b,f,g,h)
Columbus Bolt & Forging Co., Ohio (a,b,g)
Deringer Metallurgical Corp., Ill (a, b,c,d,f,g)
Division Lead Co., Ill (d)
Eaton Mfg. Co., Reliance Div., Ohio (a,g)
Elco Tool & Screw Corp., Ill (a,b,c,g)
Electric Materials Co., Pa (b)
General Chain & Mfg. Corp., Ohio (g)
General Findings & Supply Co., Industrial Div. Mass (b,f)
Gibson Electric Co., Pa (f)
Greene, G.G Corp., Pa (g)
Grip Nut Co., Ind (a,b,g)
Harper, H.M. Co., Ill (a,b,f,g,h)
Hartford Machine Screw Co., Div. of Standard Screw Co., Conn (a,b,c,f,g)
Hassall, John, Inc., NY (a,b,c,d,f,g)
Hercules Fastener Co., Ill (a,b,c,g,j)
Huck Mfg. Co., Mich (a,g)
Jaques Co., Mass (a,b,e,f,g,h)
Johnston & Funk Titanium Corp., Ohio (h)
Koehler Mfg. Co., Mass (c)
Lamson & Sessions Co., Ohio (a,b,c,f, g,h)
McKinney Mfg. Co., Pa (a,b,c,d,f,g)
Metal Goods Corp., Mo (f)
Mid-West Screw Products Co., Mo (a, b,c,g)
Milford Rivet & Machine Co., Conn (a,b,c,g)
Midland Screw Corp., Ill (a,b,c,d,e, f,g,j)
Murray Tube Works, Inc., NJ (a,b,j)
National Lock Co., Ill (a,b,c,d,g)
National Lock Co., Fastener Div., Ill (a,b,c,d,g)
National Screw & Mfg. Co., Ohio (a,b, f,g)
Parish Pressed Steel Div., Dana Corp., Pa (g)
Pheoll Mfg. Co., Inc., Ill (a,b,c,g)
Plume & Atwood Mfg. Co., Conn (a,b, g)
Pusey & Jones Corp., Del (c)
Reed & Prince Mfg. Co., Mass (a, b,c,g)
Republic Steel Corp., Ohio (g)
Rockwell Engineering Co., Ill (a,b,c, g)
Rome Mfg. Div., Revere Copper & Brass, Inc., NY (a,b)
Russell, Burdsall & Ward Bolt & Nut Co., NY
(a,b,g)—Ad p 501
Scovill Mfg. Co., Mill Products Div., Conn (a,b)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Shakeproof Div., Illinois Tool Works, Ill (a,b,g)
Standard Pressed Steel Co., Pa (a,b,f,g,h)
Thompson-Bremer & Co., Ill (a,b,c,f,g,h)
Townsend Co., Engineered Fasteners Div., Pa (a,b,g)
Tubular Rivet & Stud Co., Mass (a,b,c,f,g)
Union Screw & Mfg. Co., Pa (a,g)
United Screw & Bolt Corp., Ill (a,b,g)
United-Carr Fastener Corp., Mass (b,g)
Weatherhead Co., Ind (g)
Wesbar Stamping Corp., Wis (a,c,g)
Western Automatic Machine Screw Co., Div. of Standard Screw Co., Ohio (a,b,c,f,g)
Zeller Corp., Ohio (g)

Columbium and Its Alloys

American Silver Co., NY (v,dd,ee,ff)
Bishop, J. & Co. Platinum Works, Pa (ee)
Bridgeport Brass Co., Conn (ee)
Damascus Tube Co., Pa (ee)
du Pont de Nemours, E. I. & Co., Inc., Del (w)
Fansteel Metallurgical Corp., Ill (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)—Ad p 174
General Electric Co., Metallurgical Products Dept., Mich (q,w,aa,bb,cc,dd)
Hamilton Watch Co., Precision Metals Div., Pa (v,dd)
Hardy, Charles, Inc., NY (aa)
Hoskins Mfg. Co., Mich (ff)
Johnston & Funk Titanium Corp., Ohio (bb,ff)
Kawecki Chemical Co., NY (o,q,v,w,z,aa,bb,cc,dd,ff)
Kennametal, Inc., Pa (o,v,aa,dd)—Ad p 306
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (o,ee)
Mallory-Schwarzkopf Metals, Inc., NY (o,v,w,z,bb,cc,dd,ee,ff)
Molybdenum Corp. of America, Pa (o,w,z,aa,bb,cc,dd)
Nuclear Metals, Inc., Mass (w,bb,dd,ee)
Oregon Metallurgical Corp., Ore (w)
Rodney Metals, Inc., Mass (v)
Shieldalloy Corp., NJ (o,aa)
Stauffer-Temescal Co., Calif (o,q,v,w,z,bb,cc,dd,ee,ff)
Superior Tube Co., Ill (ee)—Ad pp 414-415
Techalloy Co., Inc., Pa (dd,ff)
Texas Instruments, Inc., Metals & Controls Div., Mass (v,dd)
Tube Distributors Co., Inc., NY (ee)
Tube Reducing Corp., NJ (ee)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (w,aa)—Ad p 181
United Screw & Bolt Corp., Ill (bb,cc,dd,ff)
Universal-Cyclops Steel Corp., Pa (o,q,z,cc)
Vanadium Corp. of America, NY (w)
Wah Chang Corp., NY (n,v,w,aa,bb,dd,ff)—Ad p 164
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb,cc,dd,ee)

Composition Board

(see Wood)

Compression Moldings

(see Moldings)

Conversion Coatings, Anodic

(anodizers)

Abalon Precision Mfg. Corp., NY
Abco Aluminum & Brass Works, Tex
Accurate Anodizing Corp., Ill
Acme Plating Co., Ohio
Aerolite Extrusion Co., Ohio
Alchemize Corp., Ill
Aluminum Billets, Inc., Ohio
Aluminum Finishing Corp., Ind
Aluminum Specialty Co., Wis
American Emblem Co., Inc., NY
Auld, D.L. Co., Ohio
B & T Metals Co., Ohio
Badger Aluminum Extrusions, NY
Biddle Screw Products Co., Ind
Bonnell, William L. Co., Inc., Ga
Briggs-Shaffner Co., NC
Brinkerhoff Brass & Bronze Works, Inc., NY
Brown Lipe Chapin Div., General Motors Corp., NY
Brooks & Perkins, Inc., Mich
Chicago Thrift-Etching Corp., Ill
Coil Anodizers, Inc., Mich
Colonial Alloys Co., Pa
Commercial Screw Products Co., Ohio
Corson Industries, Pa
Croname, Inc., Ill
Designers Metal Corp., Ill
Diversey Corp., Metal Industries Div., Ill
Doehler-Jarvis Div., National Lead Co., Ohio
Dollin Corp., NJ
Edna Lite Optical Co., Inc., NY
Engineering Products & Specialties, Inc., RI
Fox Co., Ohio
General Extrusions, Inc., Ohio
Hull, R.O. & Co., Inc., Ohio
Industrial Chromium Corp., Mass
Jarl Extrusions, Inc., NY
Jervis Corp., Mich
Kees, F.D., Mfg. Co., Neb
Kinkead Industries, Inc., Ill
Leed, H.A. Corp., Conn
Magnesium Co. of America, Ind
Magnesium Elektron, Inc., NY
Merz Machine & Tool Works, Ind
Metal Finishers, Inc., Md
Mirro Aluminum Co., Wis
Modern Plating Corp., Ill
National Aluminum Co., Ohio
National Galvanizing Co., Pa
National Gasket & Washer Mfg. Co., Inc., NY
National Lock Co., Ill
Nylok Corp., NJ
Olean Electro Plating Co., NY
Pfister Tubing Corp., NJ
Plume & Atwood Mfg. Co., Conn
Promat Div., Poor & Co., Ill
Reed & Prince Mfg. Co., Mass
Reynolds Metal Co., Va
Rustproofing & Metal Finishing Corp., Mass
Sager Metal Strip Co., Ill
Sanford Process Co., Inc., Calif
Saramar Aluminum Co., Ohio
Schwartz Chemical Co., Inc., NY
Southern Aluminum Finishing Co., Inc., Ga
Spencer Nahm Co., Calif
Stevens, Frederic B, Inc., Mich
Trenton Pipe Nipple Co., NJ
Trim Alloys, Inc., Mass
Vanamatic Co., Ohio
W L S Stamping Co., Ohio
Woodstock Div., Electric Autolite Co., Ill
Youngstown Mfg. Inc., Ohio

Conversion Coatings, Chromate

(formulations)

Abalon Precision Mfg. Corp., NY
Acme Plating Co., Ohio
Alchemize Corp., Ill
Allied Chemical Corp., Solvay Process Div. NY —Ad p 349
Allied Research Products, Inc., Md —Ad p 358
Amchem Products, Inc., Pa
Chemical Corp., Mass —Ad p 360
Colonial Alloys Co., Pa
Conversion Chemical Corp., Conn
Diamond Alkali Co., Ohio
Dollin Corp., NJ
Enthone, Inc., Conn
Heatbath Corp., Mass
Hull, R.O. & Co., Inc., Ohio
Lacquer & Chemical Corp., NY
MacDermid, Inc., Conn
Metal & Thermit Corp., NJ
Mitchell-Bradford Chemical Co., Conn
Modern Plating Corp., Ill
Neilson Chemical Co., Mich
Nylok Corp., NJ
Oakite Products, Inc., NY
Octagon Process, Inc., NY
Parker Paint Mfg. Corp., Ind
Parker Rust Proof Co., Mich
Pennsalt Chemicals Corp., Pa
Pierce & Stevens Chemical Corp., NY
Prestole Corp., Ohio
Promat Div., Poor & Co., Ill
Thompson & Co., Pa
Turco Products, Inc., Calif
Vanamatic Co., Ohio
Woodstock Div., Electric Autolite Co., Ill
Zeller Corp., Ohio

Conversion Coatings, Chromate

(coaters)

Abalon Precision Mfg. Corp., NY
Accurate Anodizing Corp., Ill
Acme Plating Co., Ohio
Amchem Products, Inc., Pa
American Agile Corp., Ohio
American Emblem Co., Inc., NY
Brooks & Perkins, Inc., Mich
Clad-Rex Corp., Ill
Colonial Alloys Co., Pa
Diversey Corp., Metal Industries Div., Ill
Dollin Corp., NJ
Du-Wel Metal Products, Inc., Mich
Eaton Mfg. Co., Reliance Div., Ohio
Electrofilm, Inc., Calif
Falstrom Co., NJ
Farwell Metal Fabricating, Minn
Hardy Mfg. Corp., Ind
Kelley Mfg. Co., Tex
Lacquer & Chemical Corp., NY
Metal Finishers, Inc., Md
Metal & Thermit Corp., NJ
Modern Plating Corp., Ill
National Lock Co., Ill
Norgren-Stemac, Inc., Colo
Nylok Corp., NJ
Olean Electro Plating Co., NY
Prestole Corp., Ohio
Promat Div., Poor & Co., Ill
Rustproofing & Metal Finishing Corp., Mass
Sommer Metalcraft Corp., Ind
Spencer Nahm Co., Calif
United-Carr Fastener Corp., Mass
W L S Stamping Co., Ohio
Witt Cornice Co., Galvanizing Div., Ohio
Worth Co., Wis
Zeller Corp., Ohio

Conversion Coatings, Oxide

(formulations)

Birchwood Chemical Co., Minn
Dollin Corp., NJ
Du-Lite Chemical Corp., Conn
Enthone, Inc., Conn
Heatbath Corp., Mass
Houghton, E.F. & Co., Pa
Hull, R.O. & Co., Inc., Ohio
MacDermid, Inc., Conn
Mitchell-Bradford Chemical Co., Conn
Modern Plating Corp., Ill
Neilson Chemical Co., Mich
Nylok Corp., NJ
Parker Paint Mfg. Corp., Ind
Prestole Corp., Ohio
Promat Div., Poor & Co., Ill
Tube Reducing Corp., NJ
Union Carbide Metals Co., Div. of Union Carbide Corp., NY
Vanamatic Co., Ohio
Zeller Corp., Ohio

Conversion Coatings, Oxide

(coaters)

Biddle Screw Products Co., Ind
Diversey Corp., Metal Industries Div., Ill
Dollin Corp., NJ
Kelley Mfg. Co., Tex
Metal Finishers, Inc., Md
Metallizing Co. of Los Angeles, Inc., Calif
Modern Plating Corp., Ill
National Lock Co., Ill
Nylok Corp., NJ
Plume & Atwood Mfg. Co., Conn
Prestole Corp., Ohio
Rustproofing & Metal Finishing Corp., Mass
Spencer Nahm Co., Calif
United-Carr Fastener Corp., Mass
W L S Stamping Co., Ohio
Worth Co., Wis

Conversion Coatings, Phosphate

(formulations)

Ainsworth Precision Castings Co., Div. of Harsco Corp., Mich
Amchem Products, Inc., Pa
Ashtabula Mfg. Co., Ohio
Detrex Chemical Industries, Inc., Mich
Dollin Corp., NJ
Enthone, Inc., Conn
Farrelloy Co., Pa
Fidelity Chemical Products Corp., NJ
Houghton, E.F. & Co., Pa
Hull, R.O. & Co., Inc., Ohio
Kelite Corp., NJ
MacDermid, Inc., Conn
Magnuson Products Corp., NY
Mitchell-Bradford Chemical Co., Conn
Modern Plating Corp., Ill
Neilson Chemical Co., Mich
Northwest Chemical Co., Mich
Nylok Corp., NJ
Oakite Products, Inc., NY
Octagon Process Inc., NY
Panther Chemical Corp., Tex
Parker Rust Proof Co., Mich
Pennsalt Chemicals Corp., Pa
Plume & Atwood Mfg. Co., Conn
Prestole Corp., Ohio
Promat Div., Poor & Co., Ill
Rustproofing & Metal Finishing Corp., Mass
Sharon Steel Corp., Pa
Thompson & Co., Pa
Turco Products, Inc., Calif
Union Carbide Metals Co., Div. of Union Carbide Corp., NY
Vanamatic Co., Ohio
Whitfield Chemical Co., Mich
Wyandote Chemicals Corp., Mich
Zeller Corp., Ohio

Conversion Coatings, Phosphate

(coaters)

Almco Steel Products Corp., Ind
Amchem Products, Inc., Pa
Ashtabula Mfg. Co., Ohio

Biddle Screw Products Co., Ind
Brandt, Charles T., Inc., Md
Clad-Rex Corp., Ill
Diversey Corp., Metal Industries Div., Ill
Doffin Corp., NJ
Electrofilm, Inc., Calif
Falstrom Co., NJ
Farwell Metal Fabricating, Minn
Grand Rapids Brass Co., Mich
Hardy Mfg. Corp., Ind
Kelley Mfg. Co., Tex
Metal Finishers, Inc., Md
Modern Plating Corp., Ill
National Lock Co., Ill
National Metal Products Co., Pa
Nylok Corp., NJ
Prestole Corp., Ohio
Rustproofing & Metal Finishing Corp., Mass
Spencer Nahm Co., Calif
United Shoe Machinery Corp., Mass
United-Carr Fastener Corp., Mass
W L S Stamping Co., Ohio
Witt Cornice Co., Galvanizing Div., Ohio
Woodstock Div., Electric Autolite Co., Ill
Worth Co., Wis

Copper and Its Alloys

Acme Tube, Inc., NJ (ee)
Ajax Metal Div., H. Kramer Co., Pa (w)
Alcasco Foundry, Ill (w)
Allied Research Products, Inc., Md
(n)—Ad p 358
Alloy Metal Products, Inc., Iowa (o,w)
Alofs Mfg. Co., Mich (dd)
Alpha Wire Corp., NY (ff)
American Brass Co., Sub. of Anaconda Co., NY (n,o,z,bb,cc,dd,ee,ff)
American Crucible Products Co., Ohio (o)
American Manganese Bronze Co., Pa (o,bb)
American Metal Climax, Inc., Amco Div., NY
(n,o,q,w,aa)—Ad pp 165-168
American Metal Climax Inc., NY (n, o,q,w,aa)
American Nickel Alloy Mfg. Corp., NY (o)
American Silver Co., NY (v,dd,ee,ff)
American Smelting & Refining Co., NY (n,q,w)
American Steel and Wire Div., U. S. Steel Corp., Ohio (ff)
Ampco Metals, Inc., Wis (o,z,cc,dd,ee)
Anaconda Co., NY (n,q,v,w,cc)
Arcos Corp., Pa (ff)
Atlantic Powdered Metals, Inc., NY (aa)
Atlantic Steel Co., Ga (cc,dd)
Atlas Brass Foundry, Calif (o)
Auld, D.L. Co., Ohio (n,cc,dd,ff)
Avins Industrial Products Corp., NY (ee)
Avril, G.A. Co., Ohio (w)
Babson Dow Mfg. Co., Mass (o)
Baer Bros. Bronze Powder Co., Inc., Mass (aa)
Bart Mfg. Corp., NJ (aa)
Barth Smelting Corp., NJ (w)
Bay State Refining Co., Inc., Mass (w)
Belmont Smelting & Refining Works, Inc., NY (n,q,w,aa)
Beryllium Corp., Pa
(o,q,w,z,bb,cc,dd,ee,ff)—Ad p 157
Biddle Screw Products Co., Ind (o,bb, ee)
Bohn Aluminum & Brass Corp., Mich (bb,ff)
Both, O.A. Corp., Mass (aa)
Bridgeport Brass Co., Conn
(n,o,bb,cc,dd,ee,ff)—Ad p 176
Bridgeport Rolling Mills Co., Conn (dd)
Brinkerhoff Brass & Bronze Works, Inc., NY (z,bb,cc,dd,ee,ff)
Bristol Brass Corp., Conn (o,z,bb,cc, dd,ff)
Brush Beryllium Co., Ohio (o,q,w,z,dd)
Bullock, W.J., Inc., Ala (w)
Cerro de Pasco Sales Corp., NY (w,ee,ff)
Chase Brass & Copper Co., Sub of Kennecott Copper Corp., Conn (n,o, z,bb,cc,dd,ee,ff)
Chicago Extruded Metals Co., Ill (bb)
Clark Perforating Co., Mich (cc,dd)
Columbia-Geneva Steel Div., U.S. Steel Corp., Calif (ff)
Continuous Cast Products Dept., American Smelting & Refining Co., NJ
(o,q,bb,ee)—Ad p 433
Copper & Brass Sales, Inc., Mich (n, o,q,v,z,bb,cc,dd,ee,ff)
Craft Metal Spinning Co., Ill (cc)
Crescent Bronze Powder Co., Ill (aa)
Crucible Steel Co. of America, Titanium & Vacuum Metals Product Div., Pa (o,q,w,z,cc,dd)
Designers Metal Corp., Ill (cc)
Detroit Float & Stamping Co., Mich (o,bb,dd,ee)
Dixon Sintaloy, Inc., Conn (o)
Dormont Mfg. Co., Pa (ee)
Driver, Wilbur B. Co., NJ
(v,bb,dd,ff)—Ad p 185
Driver-Harris Co., NJ (bb,dd)
Dudek & Bock Spring Mfg. Co., Ill (ff)
Eastern Rolling Mills, Inc., NY (cc, dd)
Electric Materials Co., Pa (n,o,bb)
Electronic Parts Mfg. Co., Inc., NJ (ff)
Empire Metal Co., NY (n,o)
Erskine Precision Wire Corp., Pa (ff)
Essex Industrial Products Div., Essex Wire Corp., Ind (ff)
Essex Wire Corp., Magnet Wire Div., Ind (ff)
Eynon-Dakin Co., Mich (ee)
Federated Metals Div., American Smelting and Refining Co., NY (n, o,q,w,bb,ee)
Fromson Orban Co., Inc., NY (z,cc, dd,ee)
General Cable Corp., NY (ff)
Glidden Co., Ind (aa)
Glidden Co., Chemical Divs., Metals Dept., Ind
(aa)—Ad p 429
Gold Leaf & Metallic Powders, Inc., NY (aa)
Grand Rapids Brass Co., Mich (z)
Greenback Industries, Inc., Mich (aa)
H & H Tube & Mfg. Co., Mich (b)
Hamilton Watch Co., Precision Metals Div., Pa (v,bb,cc,dd,ff)
Hardy, Charles, Inc., NY (aa)
Harris, Benjamin & Co., Ill (w)
Harshaw Chemical Co., Ohio (n)
Harvey Aluminum, Calif (o,bb)
Hayden Wire Works, Inc., Mass (ff)
Hettleman K. & Sons., Inc., Md (w)
Hodgson Foundry Co., Ill (n,o,z)
Hoffman Bronze & Aluminum Casting Co., Ohio (n)
Hommel, O. Co., Pa (aa)
Horton-Angell Co., Mass (n,o,bb,cc,dd, ee,ff)
Hoskins Mfg. Co., Mich
(bb,dd)—Ad p 177
Houston Blow Pipe & Sheet Metal Works, Tex (o,cc)
Hudson, Inc., NJ (w)
Hull, R.O. & Co., Inc., Ohio (n)
Hussey, C.G. & Co., Div. of Copper Range Co., Pa
(n,o,z,bb,cc,dd,ee,ff)—Ad p 180
Inshield Die & Stamping Co., Ohio (dd)
Inspiration Consolidated Copper Co., NY (n,o,q)
Instrument Specialties Co., Inc., NJ
(dd)—Ad p 463
International Minerals and Metals Corp, NY (w)
International Powder Metallurgy Co., Inc., Pa (z,aa,ee)
Jelliff, C.O. Mfg. Corp., Conn (ff)
Jordan-Rogers Co., Calif (ff)
K. & L. Plating Co., Pa (z)
Kassel Export Co., Inc., NJ (v,ff)
Kelsey-Hayes Co., Metals Div., NY (o,q,v,w,z,bb,cc,dd,ff)
Kenmore Machine Products, Inc., NY (ee)
Kinkead Industries, Inc., Ill (cc,dd)
Lakeland Industries, Minn (z)
Laminated Shim Co., Conn (cc)
Langsenkamp, F.H. Co., Ind (o,z,bb, cc,dd,ee,ff)
Lavin, R. & Sons, Inc., Ill (n,w)
Leach & Garner Co., Industrial Div., Mass (v,bb,cc,dd,ee,ff)
Lewin-Mathes Div., Cerro De Pasco Corp., Mo (q,w,bb,ee)
Loewenthal Metals Corp., Ill (w)
Lundquist Tool & Mfg. Co., Inc., Mass (cc,dd)
Mackenzie Walton Corp., RI (ee)
Magna Mfg. Co., Inc., NJ (aa)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (o,dd,ee,ff)
Mallory, P.R. & Co., Inc., Ind (o, bb,dd,ff)
Malone Bronze Powder Works, Inc., NY (aa)
Malone Metal Powders, Inc., NJ (aa)
McGean Chemical Co., Ohio (n,aa,dd)
McGregor-Michigan Corp., Mich (ee)
Metal & Thermit Corp., NJ (n)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Metals Disintegrating Co., Inc., NJ (aa)
Miller Co., Conn (dd)
Modern Plating Corp., Ill (n,o,dd,ff)
Mueller Brass Co., Mich (bb)
Murray, A.B. Co., Inc., NJ (ee)
National Electric Div., H.K. Porter Co., Pa (ff)
National Lead Co., NY (ee)
Nesor Alloy Products Co., NJ (dd,ff)
New England Brass Co., Mass (cc,dd)
New England Electrical Works, Inc., NH (ff)
New England Smelting Works, Inc., Mass (w)
New Jersey Zinc Co., NY
(aa)—Ad pp 452-453
New Haven Copper Co., Conn (n,z,cc, dd)
New Jersey Metals Co., NJ (n,w)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Nippert Electric Products Co., Ohio (bb,dd)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb)
Norwalk Powdered Metals, Inc., Conn (aa)
Okonite Co., Sub. of Kennecott Copper Corp., NJ (bb,ff)
Olds Alloys Co., Calif (ee)
Olin Mathieson Chemical Corp., Metals Div., NY
(cc,dd)—Ad p 155
Ormond Mfg. Co., Inc., NJ (dd,ff)
Peerless Roll Leaf Co., Div. of Howe Sound Co., NJ (v,dd)
Penn Brass & Copper Co., Pa (ee)
Phelps Dodge Copper Products Corp., NY (dd)
Phelps Dodge Refining Corp., NY (n,o)
Plume & Atwood Mfg. Co., Conn (bb, cc,dd,ff)
Precision Tube Co., Inc., Pa (ee)
Rathbone Corp., Mass (o,bb)
Republic Metals Co., Inc., NY (n,w)
Revere Copper & Brass, Inc., NY (n, o,v,z,bb,cc,dd,ee)
Revere Copper & Brass, Inc., Foil Div., NY (v)
Reynolds Aluminum Supply Co., Ga (o, bb,cc,dd,ee)
Rigidized Metals Corp., NY (cc,dd)
River Smelting & Refining Co., Ohio (w)
Riverside-Alloy Metal Div. H.K. Porter Co., Inc., NJ
(bb,dd,ff)—Ad p 160
Rodney Metals, Inc., Mass (v,dd)
Roebling's, John A. Sons Div., Colorado Fuel & Iron Corp., NJ (bb,dd, ff)
Rome Mfg. Div., Revere Copper & Brass, Inc., NY (n)
Saginaw Bearing Co., Mich (o,q)
Sall, George Metals Co., Inc., Pa (w)
Sandusky Foundry & Machine Co., Ohio (ee)
Schumann, I. & Co., Ohio (w)
Scovill Mfg. Co., Mill Products Div., Conn
(bb,cc,dd,ee,ff)—Ad pp 169-170
Sel-Rex Corp., NJ
(n,aa)—Ad p 356
Seymour Mfg. Co., Conn
(bb,dd,ff)—Ad p 178
Shenango Furnace Co., Centrifugally Cast Products Div., Ohio (ee)
Sherwatt Equipment & Mfg. Co., Inc., NY (ff)
Sipi Metals Corp., Ill (w)
Somers Brass Co., Inc., Conn
(v,dd)—Ad p 162
Sonken-Galamba Corp., Mo (w)
Stamford Rolling Mills Co., Inc., Conn (cc)
Standard Metals Corp., Mass (ee,ff)
Star Heel Plate Co., Inc., NJ (ff)
Stauffer-Temescal Co., Calif (q,w)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Stevens, Frederic B., Inc., Mich (n)
Sylvania Electric Products, Inc., Parts Div., Pa (ff)
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (ff)
Terre Haute Bronze & Brass Foundry, Ind (bb,cc,dd,ee)
Texas Instruments, Inc., Metals & Controls Div., Mass (v)
Thinsheet Metals Co., Conn (cc)
Titan Metal Mfg. Co., Pa (o,bb)
Triangle Conduit & Cable Co., Inc., NJ (bb,ee,ff)
Udylite Corp., Mich (n,o,bb)
Ullmann, Inc., Wis (o,ee)
U.S. Bronze Powder Works, Inc., NJ (aa)
U.S. Metal Products Co., Pa (w)
United Wire & Supply Corp., RI (ee,ff)
Universal Castings Corp., Ill (w)
Utility Mfg. Co., Mass (o,bb)
Viking Copper Tube Co., Ohio (ee)
Volco Brass & Copper Co., NJ (cc)
Wallace Tube Co., Div. of Wallace Supplies Mfg. Co., Ill (ee)
Waterbury Rolling Mills, Inc., Conn (cc,dd)
Wells, A.H. & Co., Inc., Conn (ee)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb, cc,dd,ee)
Whitaker Metals Corp., Mo (aa)
Whitehead Metal Products Co., Inc., NY (o,z,bb,cc,dd,ee,ff)
Wisconson Centrifugal Foundry, Inc., Wis (ee)
Wright, Albert Screw Machine Products, Calif (bb)

Cordierite

(see Ceramics)

Cork

Armstrong Cork Co., Pa (r)
Conolite Div., Continental Can Co., Del (bb,cc,ee)
Coyne & Paddock, Inc., NY (cc)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (r,aa,cc)
Dutch Brand Div., Johns-Manville Corp., Ill (r,cc)
Enamel Products Co., Ohio (r)
General Gasket, Inc., Conn (r)
Hollingsworth & Vose Co., Mass (r)
National Gasket & Washer Mfg. Co., Inc., NY (r,cc)
Newth Rubber Co., RI (cc)
Peerless Products Industries, Ill (r)
Sheller Mfg. Corp., Mich (r,bb,cc,ee)
Silicocks Miller Co., NJ (r)
Spring Packing Corp., Ill (r)
Staver Co., Inc., NY (r,cc)
Superior Mfg. Co., Pa (r)
United Cork Cos., NJ (r)
Wisconsin Gasket & Mfg. Co., Wis (r)

Corrugated Metals

Aetna Steel Co., Fla (g)
Albert Pipe Supply Co., Inc., NY (g)
Aluminum Co. of America, Pa (a)
Armco Steel Corp., Ohio (g)
Atlantic Steel Co., Ga (g)
Bethlehem Steel Co., Pa (g)
Biersach & Niedermeyer Co., Wis (a,b,g)
Cartwright, R. Tube Products Co., Mich (a)
Clendenin Bros., Inc., Md (a)
Cobra Metal Hose Div., DK Mfg. Co., Ill (b,f,h)
Colonial Alloys Co., Pa (a)
Conner Mfg. Co., Ky (c)
Edgcomb Steel & Aluminum Corp., NJ (a,g)
Electric Steel Foundry Co., Ore (g)
Empire-Reeves Steel Div., Universal-Cyclops Steel Corp., Pa (g)
Gulfoy Cornice Works, Calif (a,c)
Illinois Zinc Co., Div. of Hydrometals, Inc., Ill (j)
Inland Steel Co., Ill (g)
Johnson Metal Hose, Inc., Conn (b,f,g)
Jones & Laughlin Steel Corp., Pa (g)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Kelley Mfg. Co., Tex (a,g)
Levinson Steel Co., Pa (a,g)
New York Iron Roofing & Corrugating Co., Inc., NJ (a,g)
Olin Mathieson Chemical Corp., Metals Div., NY (a)
Powell Pressed Steel Co., Ohio (a,g)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY (a,b)
Reynolds Aluminum Supply Co., Ga (a,g)
Reynolds Metals Co., Va (a)
Rockwell Engineering Co., Ill (a,b,c,g)
Ryerson, Joseph T. & Son, Inc., Ill (g)
Staver Co., Inc., NY (a,b,c,d,e,f,g,h,j)
Sun Steel Co., Ill (a,g,h)
U.S. Steel Corp., Pa (g)

Cupro-Nickel

(see Copper)

Diallyl Phthalate

(DAP)
Alcylite Plastics & Chemical Corp., Calif (x,y)
Chemicals & Plastics Div., Food Machinery & Chemical Corp., NY (p,x,y)
Cordo Chemical Corp., Conn (x,y)
Cordo Molding Products, Inc., Conn (y)
Durez Plastics Div., Hooker Chemical Corp., NY
(y)—Ad pp 232-233
Dyna-Therm Chemical Corp., Calif (p)
F M C Organic Chemicals Div., Food Machinery & Chemical Corp., NY (p)
Fiber Glass Industries, Inc., NY (x,y,cc)
Formica Corp., Sub. of American Cyanamid Corp., Ohio (bb,cc,dd)
Hays Mfg. Co., Pa (y)
Maloney, F.H. Co., Tex (y)
Mesa Plastics Co., Calif (p,y,bb,cc)
Rogers Corp., Conn
(y)—Ad p 261
Specialty Resins Co., Calif (p,x)
Synthane Corp., Pa (bb,cc,dd,ee)
U.S. Polymeric Chemicals, Inc., Conn (s)

Die Castings

(see Castings)

Diffusion Coatings

(calorized, chromized, sherardized)
Alloy Surfaces Co., Inc., Del
Calorizing Co., Pa
Chromalloy Corp., NY
Chromizing Corp., Calif
Colonial Alloys Co., Pa
General Extrusions, Inc., Ohio
Kelley Mfg. Co., Tex
Metal Finishers, Inc., Md
Modern Plating Corp., Ill
Nylok Corp., NJ
Sheldon, M.L. & Co., Inc., NY
Tickle, Arthur Engineering Works, Inc., NY
Vanamatic Co., Ohio

Dip Coatings

(see Immersion Coatings; Galvanizers)

Dispersion Coatings

(see Organic Coatings)

Drawn, Pressed Parts

(not incl. stampings)
Abalon Precision Mfg. Corp., NY (a,b,c,g)
Ackermann Mfg. Co., W. Va (g)
Acme Metal Spinning, Inc., Minn (a,b,c,d,e,f,g,h,j)
Acme Stamping & Wire Forming Co., Pa (a,b,g)
Acorn Sheet Metal Mfg. Co., Inc., Ill (a,g)
Alco Products, Inc., NY (g)
AllianceWall Div., AllianceWare, Inc., Ohio (g)
Alloy Products Corp., Wis (a,f,g,h)
Aluminum Co. of America, Pa (a)
Aluminum Goods Mfg., Wis (a,g)
Aluminum Specialty Co., Wis (a,g)
American Aluminum Co., NJ (a,b)
American Brass Co., Sub. of Anaconda Co., NY (b)
American Car & Foundry Div., ACF Industries, Inc., NY (a,e,g)
American Forge & Mfg. Co., Pa (g)
American Machine & Foundry Co., Cleveland Welding Div., Ohio (f,g,h)
American Silver Co., Inc., NY (a,b,e,f,g)
Anchor Metal Spinning Co., Ohio (a,b,c,d,f,g)
Anthes Div., Gleason Corp., Iowa (a,g)
Armco Steel Corp., Sheffield Div., Mo (g)
Arrow Metal Products Corp., NJ (a)
Arvin Industries, Inc., Ind (a,g)
Associated Spring Corp., Wallace Barnes Steel Div., Conn (g)
Atlas Metal Parts Co., Wis (a,b,c,g)
Auld, D.L. Co., Ohio (c)
Belmont Smelting & Refining Works, NY (a,b,g)
Bethlehem Steel Co., Pa (g)(a,b,g)
Boots Aircraft Nut Corp., Conn (g)
Brandt, Charles T., Inc., Md (a,b,e,g)
Brooks & Perkins, Inc., Mich
(a,e,g,h)—Ad p 457
Brown Lipe Chapin Div., General Motors Corp., NY (g)
Cly-Del Mfg. Co., Conn (a,b,f,g,j)
Colonial Alloys Co., Pa (a)
Columbus Bolt & Forging Co., Ohio (a,b,g)
Commercial Shearing & Stamping Co., Ohio (a,f,g)
Consolidated Fruit Jar Co., NJ (a,b,c,d,g,j)
Cooley, W.J. & Co., Tenn (a,b,c,g)
Crosby Co., NY (a,b,g)
Crown Metal Co., Wis (d)
Crucible Steel Co. of America, Pa (g,h)
Cuyahoga Stamping Co., Ohio (a,b,g)
Cyril Bath Co., Ohio (a,e,f,g,h)
Dahlin, C. A. Co., Ill (a,b,d,e,f,g,j)
Dana Corp., Auburn Div., Ind (g)
Dayton Rogers Mfg. Co., Minn (a,b,c,g,j)
Detroit Stamping Co., Mich (a,b,g)
Dirilyte Co. of America, Inc., Ind (a,b)
Division Lead Co., Ill (d)
Dow Chemical Co., Dow Metal Products Co. Div., Mich (e)
Eastern Tool & Mfg. Co., NJ (a,b,c,d,g,h)
Eastern Tool & Stamping Co., Inc., Mass (a,b,c)
Eaton Mfg. Co., Reliance Div., Ohio (g)
Edgcomb Steel & Aluminum Corp., NJ (g)
Electric Autolite Co., Ohio (c)
Electric Materials Co., Pa (b)
Electric Steel Foundry Co., Ore (g)
Etched Products Corp., NY (a,b,g)
Evans, George Corp., Ill (a)
Falstrom Co., NJ (a,b,e,f,h)
Farwell Metal Fabricating, Minn (a,b,e,f,g)
Fletcher Enamel Co., W. Va (a,b,c,d,e,f,g)
Forg, Peter Mfg. Co., Mass (a,b,c,h)
Frasse, Peter A. & Co., Inc., NY (a,g)
Garco Mfg. Co., Inc., Ill (a,b,c,e,f,g,h,j)
General Alloys Co., Mass (a,b,f)
General Findings & Supply Co., Industrial Div., Mass (b,f,g)
Geuder, Paeschke & Frey Co., Wis (a,c,f,g)
Grammes, L.F. & Sons, Inc., Pa (a,b,c,g)
H & H Tube & Mfg. Co., Mich (b)
Hydroforming Co. of America, Ill (a,b,f,g,h)
Ideal Can Co., Mass (a,b,g)
Illinois Zinc Co., Div. of Hydrometals, Inc., Ill (j)
Ingersoll Products Div., Borg-Warner Corp., Ill (g)
Inland Steel Co., Ill (g)
International Silver Co., Eyelet Specialty Div., Conn (a,b,g)
Irwin-Sensenich Corp., Pa (g)
Jones & Laughlin Steel Corp., Pa (g)
Kees, F.D. Mfg. Co., Neb (a,g)
Kelley Mfg. Co., Tex (a,g)
Kelsey-Hayes Co., Mich (g)
Kling Metal Spinning & Stamping Co., NY (a,b,c,d,e,f,g,j)
Koehler Mfg. Co., Mass (a,b,c,g)
Lakewood Metal Products, Inc., Conn
Lansing Stamping Co., Mich (g)
Latrobe Steel Co., Pa (g)
Leake Engineering Co., Mich (a,b,c,d,e,f,g,h,j)
Leake Stamping Div., Monarch Products Co., Mich (a,b,f,g,h)
Lenape Hydraulic Pressing & Forging Co., Pa (a,b,g)
Linde Co., Div. of Union Carbide Corp., NY (g)
Lukens Steel Co., Pa (a,b,e,f,g,h)
Lundquist Tool & Mfg. Co., Inc., Mass (a,g)
Magline, Inc., Mich (a,e)
Magnesium Co. of America, Ind (a,e)
Magnesium Products of Milwaukee, Inc., Wis (a,e)
Mahon, R.C. Co., Mich (a,g)
Manganese Steel Forge Co., Pa (g)
Manufacturers Service, Inc., Ohio (a,b,g)
Matthiessen & Hegeler Zinc Co., Ill (j)
Midwest Stamping & Mfg. Co., Ohio (a,b,f,g)
Milwaukee Stamping Co., Wis (a,b,g)
Mirro Aluminum Co., Wis (a)
Morse, Fred W. Co., RI (a,b,c,g,j)
Morton Mfg. Co., Ill (a,g)
National Metal Products Co., Pa (a,b,d,g,j)
National Moldite Co., NJ (c)
Nichols, L.O. & Son Mfg. Co., Mo (a,b,c,g)
Nichols Wire & Aluminum Co., Iowa (a)
Nippert Electric Products Co., Ohio (b)
Olean Electro Plating Co., NY (a,b,g)
Olderman Mfg. Corp., Conn (b)
Olin Mathieson Chemical Corp., Metals Div., NY (b)
Parish Pressed Steel Div., Dana Corp., Pa (a,g)
Peterson Products Corp., Ill (a,b,f,g)
Phoenix Products Co., Wis (a,b,c,f,g)
Pioneer Stamped Products Co., NY (a,b,e,f,g)
Pittsburgh Steel Co., Pa (g,j)
Plume & Atwood Mfg. Co., Conn (a,b,c,f,g,l)
Polar Ware Co., Wis (a,b,f,g)
Powell Pressed Steel Co., Ohio (a,g)
Precision Extrusions, Inc., Ill (a)
Pressed Steel Co., Pa (a,b,f,g)
Pressed Steel Tank Co., Wis (a,b,c,e,f,g,h)
Queen Products Co., Inc., Ky (a,g)
Regal Ware, Inc., Wis (a,b,g)
Reichert Float & Mfg. Co., Ohio (a,b,c,d,f,j)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY (a,b)
Reynolds Metals Co., Va (a)
Rockwell Engineering Co., Ill (a,b,c,g)

Rockwell-Standard Corp., Stamping Div., NY (a,b,d,f,g)
Rohr Aircraft Corp., Calif (a,e,g,h)
Rolock, Inc., Conn (f)
Ryerson, Joseph T. & Sons, Inc., Ill (a,g)
Scalfe Co., Pa (a,b,c,e,f,g,h)
Scovill Mfg. Co., Mill Products Div., Conn (a,b,c,f,g)
Shank Metal Products Co., NY
Simonsen Metal Products Co., Ill (a,g)
Smoot-Holman Co., Calif (g)
Southern Metal Products Co., La (a,g)
Southwestern Porcelain Steel Corp., Okla (g)
Spincraft, Inc., Wis (a,b,g)
Star Stamping Co., Mich (a,b,g)
Staver Co., Inc., NY (a,b,c,d,e,f,g,h,j)
Stirrup Metal Products Corp., NJ (a,b,c,g)
Superior Mfg. Co., Pa (g)
Superior Spinning & Stamping Co., Ohio (a,b,f,g)
Sylvania Electric Products, Inc., Parts Div., Pa (a,b,c,f,g)
Teiner, Roland Co., Inc., Mass (a,b,f,g)
Texas Instruments, Inc., Metals & Controls Div., Mass (a,b,c,e,f,g,h,j)
Textile Shield Co., Inc., Mass (a,b,g)
Thompson-Bremer & Co., Ill (a,b,c,f,g,h)
Titan Metal Mfg. Co., Pa (b)
Trenton Pipe Nipple Co., NJ (b,g)
Triangle Stamping Co., Ohio (a,b,c,d,f,g,j)
United-Carr Fastener Corp., Mass (a,b,g)
Van Huffel Tube Corp., Ohio (a,b,g)
Volkert Stampings, Inc., NY (b,f,g)
Vollrath Co., Wis (g)
Vulcan-Kidd Steel Div., H.K. Porter Co. Inc., Pa (g)
Waterbury Cos., Inc., Conn (a,b,g)
Waterbury Pressed Metal Co., Conn (a,b,f,g)
Waterman Industries, Inc., Calif (a,b,g)
Wayne Foundry & Stamping Co., Mich (a,b,e,g,h)
Wesbar Stamping Corp., Wis (a,b,c,g)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (a,b,c,e,f,g)
Wilson-Hurd Mfg. Co., Inc., Wis (a)
Wisconsin Tool & Stamping Co., Ill (a,b,g)
Wolverine Tube Div., Calumet & Hecla, Inc., Mich (a)
Worcester Pressed Steel Co., Mass (a,b,c,e,f,g,h,j)
Worcester Stamped Metal Co., Mass (a,b,f,g,h,j)
Wuest Bros., Inc., Ky (a,b,c,f,g)
Wycoff Steel Co., Pa (g)
Youngstown Kitchens Div., American Standard Co., Ohio (a,g)
Youngstown Mfg., Inc., Ohio (a,g)

Drop Forgings

(see Forgings)

Ductile Iron

(see Iron)

Electrodes, Welding

(see Filler Metals)

Electroless Coatings

(see Immersion Coatings)

Electroplated Coatings

(Electroplaters; see also Preplated Metals)

Abalon Precision Mfg. Corp., NY
Accurate Anodizing Corp., Ill
Acme Plating Co., Ohio
Ainsworth Precision Castings Co., Div. of Harsco Corp., Mich
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY
Allied Research Products, Inc, Md
Aluminum Billets, Inc., Ohio
American Emblem Co., Inc., NY
American Nickeloid Co., Ill
American Platinum & Silver Div., Engelhard Industries, Inc., NY
—Ad p 159
American Smelting & Refining Co., NY
Apollo Metal Works, Ill
Atlantic Brass Works, Inc., Ill
Atlantic Steel Co., Ga
Auld, D.L. Co., Ohio
Bart Mfg. Corp., NJ
Bethlehem Steel Co., Pa
Bishop, J. & Co. Platinum Works, Pa
Boyles Galvanizing & Plating Co., Tex
Brown Lipe Chapin Div., General Motors Corp., NY
Brewer-Titchener Corp., NY
Brooks & Perkins, Inc., Mich
Chromium Corp. of America, NY
City Plating Works, Inc., Conn
Cohan Epner Co., Inc., NY
Colonial Alloys Co., Pa
Columbus Dental Mfg. Co., Ohio
Commercial Screw Products Co., Ohio
Conforming Matrix Corp., Ohio
Continental Die Casting Corp., Mich
Croname, Inc., Ill
Designers Metal Corp., Ill
Diamond Alkali Co., Ohio
Diversey Corp., Metal Industries Div., Ill
Doehler-Jarvis Div., National Lead Co., Ohio
Dollin Corp., NJ
Du-Wel Metal Products, Inc., Mich
Eaton Mfg. Co., Reliance Div., Ohio
Edna Lite Optical Co., Inc., NY
Electric Autolite Co., Ohio
Electric Materials Co., Pa
Electrolizing Corp., Ohio
Elmet Div., North American Phillips Co., Inc., Me
Fox Co., Ohio
General Chain & Mfg. Corp., Ohio
General Findings & Supply Co., Industrial Div., Mass
Grand Rapids Brass Co., Mich
Hardy Mfg. Corp., Ind
Harshaw Chemical Co., Ohio
Hilfinger Corp., Ohio
Hull, R.O. & Co., Inc., Ohio
Indium Corp. of America, NY
Industrial Chromium Corp., Mass
Jervis Corp., Mich
K. & L. Plating Co., Pa
Kees, F.D. Mfg. Co., Neb
La France Precision Casting Co., Pa
Lakeland Industries, Minn
Lea Mfg. Co., Conn
Litho-Strip Corp., M.M. Young Div., Ill
Lundquist Tool & Mfg Co., Inc., Mass
MacDermid, Inc., Conn
Marlane Development Co., Inc., NY
Master Chrome Service, Inc., Ohio
McGean Chemical Co., Ohio
Mechanical Plating Co., Ill
Medico Industries, Inc., Pa
Merrimac Brass, Mass
Metal Finishers, Inc., Md
Metal & Thermit Corp., NJ
Metaplast Process, Inc., NY
Michigan Chrome & Chemical Co., Mich
Modern Plating Corp., Ill
National Malleable & Steel Castings Co., Ohio
New Jersey Metals Co., NJ
New Jersey Zinc Co., NY
Norgren-Stemac, Inc., Colo
Nylok Corp., NJ
Olean Electro Plating Co., NY
Ormond Mfg. Co., Inc., NJ
Penn Metal Co., Inc., W. Va
Pittsburgh Steel Co., Pa
Plume & Atwood Mfg. Co., Conn
Promat Div., Poor & Co., Ill
Reed & Prince Mfg. Co., Mass
Republic Steel Corp., Ohio
Rustproofing & Metal Finishing Corp., Mass
Ryerson, Joseph T. & Son, Inc., Ill
St. Eloi Corp., Ohio
St. Louis Diecasting Corp., Mo
Seal-Peel, Inc., Mich
Sifco Metachemical, Inc., Ohio
Sommer Metalcraft Corp., Ind
Southern Metal Products Co., La
Spencer Nahm Co., Calif
Steel Protection & Chemical Co., Ind
Stevens, Frederic B., Inc., Mich
Stirrup Metal Products Corp., NJ
Sylvania Electric Products, Inc., Parts Div., Pa
Texas Instruments, Inc., Metals & Controls Div., Mass
Tiarco Corp., NJ
Trenton Pipe Nipple Co., NJ
Tubular Rivet & Stud Co., Mass
United Refining & Smelting Co., Ill
United-Carr Fastener Corp., Mass
Vanamatic Co., Ohio
Van der Horst Corp., NY
Van Valkenburg, L.D. Co., Mass
WLS Stamping Co., Ohio
Waldman, Joseph & Sons, Epoxy Products Div., NJ
Wayne Foundry & Stamping Co., Mich
Wesbar Stamping Corp., Wis
Western Coating Co., Mich
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY
Williams Gold Refining Co., Inc., NY
Woodstock Div., Electric Auto-Lite Co., Ill
Worcester Wire Works Div., National-Standard Co., Mass
Worth Co., Wis
Wright Metalcoaters, NJ
Wyandotte Chemicals Corp., Mich
Zeller Corp., Ohio

Embossed Metals

(incl. rigidized)

Aluminum Co. of America, Pa (a)
American Nickeloid Co., Ind. (a,b,g,j)
Ardmore Products, Inc., NJ (a,b,c,d,e,f,g,h,j)
Atlantic Steel Co., Ga (a,b,g)
Auld, D.L. Co., Ohio (a,b)
Biersach & Niedermeyer Co., Wis (a,b,g)
Clad-Rex Corp., Ill
Colonial Alloys Co., Pa (a)
Cooley, W.J. & Co., Tenn (a,b,c,g)
Copper & Brass Sales, Inc., Mich (a)
Croname Inc., Ill (a,b,f,g,j)
Electric Steel Foundry Co., Ore (a,b,c,g)
Fairmont Aluminum Co., Va (a)
Falstrom Co., NJ (a,b,e,f,g,h)
Grammes, L.F. & Sons, Inc., Pa (a,b,g)
Grigoleit Co., Ill (a,g)
Hawkridge Bros. Co., Mass (a)
Haydon Corp., NY (a,g)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Langsenkamp, F.H. Co., Ind (a)
Mahon, R.C. Co., Mich (a)
McKinney Mfg. Co., Pa (a,b,e,f,g)
Metal Goods Corp., Mo (a)
Morse, Fred W. Co., RI (a,b,c,g)
Olin Mathieson Chemical Corp., Metals Div., NY (a)
Pittsburgh Steel Co., Pa (g)
Premier Metal Works, Inc., Ill (a,b,f,g)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY (a)
Reynolds Aluminum Supply Co., Ga (a)
Reynolds Metal Co., Ky (a)
Rigidized Metals Corp., NY (a,b,f,g,h)
Rockwell Engineering Co., Ill (a,b,c,g)
Ryerson, Joseph T. & Son, Inc., Ill (a)
Sager Metal Strip Co., Ill (a)
Sharon Steel Corp., Pa (g)
Southern Aluminum Finishing Co., Inc., Ga (a)
Southwestern Porcelain Steel Corp., Okla (g)
Sun Steel Co., Ill (a,g,h)
Wesbar Stamping Corp., Wis (a,b,c,g)
Whitehead Metal Products Co., Inc., NY (a,b,f,g)
Wilson-Hurd Mfg. Co., Inc., Wis (a)

Emulsion Coatings

(see Organic Coatings)

Enamels

(see Organic Coatings)

Epoxies

Adhesive Products Corp., NY (x)
Aerojet-General Corp., Structural Materials Div., Calif (y,ee)
Alcylite Plastics & Chemical Corp., Calif (p)
Amercoat Corp., Calif (ee)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

American Metaseal Corp., NJ (x,ee)
American-Marietta Co., Adhesive, Resin & Chemical Div., Wash (p,y)
Angier Adhesives Div., Interchemical Corp., Mass (x)
Aries Laboratories, Inc., Conn (p,x,y)
Armstrong Products Co., Ind (x)
Atlas Mineral Products Co., Pa (x)
Biggs, Carl H. Co., Inc., Calif (t,x,y)
Bisonite Co., Inc., NY (x)
Booty Resineers Div., American-Marietta Co., Ohio (y)
Borden Chemical Div., Borden Co., NY (p)
Cadillac Plastic & Chemical Co., Mich (p,x)
Chemical Coatings & Engineering Co., Inc., Pa (p,x)
Chemical Development Corp., Mass (p, x)
Chemicals and Plastics Div., Food Machinery & Chemical Corp., NY (p,y)
Ciba Co., Inc., Plastics Div., Pa
(p,x)—Ad pp 278-279
Clinton Co., Ill (x,y)
Coast Pro-Seal & Mfg. Co., Calif (x)
Colonial Kolonite Co., Ill (bb,cc)
Comco Plastics, Inc., NY (bb,cc,dd,ee)
Continental-Diamond Fibre Corp., Del (bb,cc,dd,ee)
Co-Polymer Chemicals Inc., Mich (x)
Cordo Chemical Corp., Conn (x,y)
Cordo Molding Products, Inc., Conn (y)
Curbell, Inc., NY (bb,cc,ee)
Dayton Rubber Co., Ohio (x,y)
Dennis Chemical Co., Mo (y)
Devcon Corp., Mass (x,y)
Dow Chemical Co., Plastics Div., Mich (p)
Dyna-Therm Chemical Corp., Calif (p)
Electro Chemical Engineering & Mfg. Co., Pa (t,cc)
Electrofilm, Inc., Calif (t)
Electronic Production & Development, Inc., Chemical Div., Calif (x,y)
Emerson & Cuming, Inc., Mass (p,u, x,bb)
Fiber Glass Industries, Inc., NY (x,y, cc)
Fibercast Div., Youngstown Sheet & Tube Co., Okla (ee)
Formica Corp., Sub. of American Cyanamid Co., Ohio (cc,ee)
Foss Mfg. Co., Id (x)
Fry Plastics International, Calif (p,x)
Fuller, H.B. Co., Minn (x)
Furane Plastics, Inc., Calif (x,y)
Galigher Co., Utah (p,s,x)
General Electric Co., Laminated Products Dept., Ohio (bb,cc,ee)
General Plastics Mfg. Co., Wash (x)
Glass Reinforced Plastics Corp., Ohio (bb,ee)
Glo-Brite Products, Inc., Ill (u)
Hardman, H.V. Co., Inc, NJ (x)
Hauger-Beegle Asso., Inc., Ill (t,x)
Hiller Aircraft Corp, Adhesive Engineering Div., Calif (t,u,x)
Hysol Corp., NY (p,x,y,bb,cc,dd,ee)
Insulation Mfrs. Corp., Ill (x)
Jones-Dabney Co., Div. of Devoe & Raynolds Co., Inc., Ky (p,x)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Kish Industries, Inc., Mich (x)
Kurz, Kasch, Inc., Ohio (y)
Maloney, F.H. Co., Tex (x,y)
Marblette Corp., NY (x,y,bb)
Mesa Plastics Co., Calif (p,y,bb,cc)
Mica Corp., Calif (cc)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (cc)
Micarta Div., Westinghouse Electric Corp., SC (x,y)
Miller-Stephenson Chemical Co., Inc., Conn (p,y,bb)
Narmco Industries, Inc., Narmco Materials Div., Calif (u,x,y,dd)
National Vulcanized Fibre Co., Del (cc)
New England Laminates Co., Inc., Conn (cc)
Norrich Plastics Corp., NY (bb,cc,dd, ee)
Northern Plastics Corp., Wis (cc,dd)
Ohio Adhesives Corp., Ohio (x)
Panelyte Div., St. Regis Paper Co., NJ (x,bb,cc,dd,ee)
Permacel, NJ (p,x,y)
Philrus Products Co., NJ (bb,cc,dd,ee)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (x)
Poly Resins, Calif (p,x)
Polygon Plastic Co., Ind (ee)
Polymer Corp., Pa (y)
Porter, William Co., Calif (cc,ee)
Pyrosil, Inc., Ohio (x,cc)
Radiation Applications, Inc., NY (x)
Raybestos-Manhattan, Inc., Plastic Products Div., Pa (x,cc)
Raybestos-Manhattan, Inc., Raybestos Div., Conn (p,x)
Reichhold Chemicals, Inc., NY (p,x)
Ren Plastics, Inc., Mich (p,s,x,y,ee)
Reynolds Chemical Products Co., Mich (p,x)
Rezolin, Inc., Calif (p,x)
Richardson Co., NY (bb,cc,ee)
Rogers Corp., Conn (y)
Roller Reinforced Plastics, Ohio (x)
Schwartz Chemical Co., Inc., NY (x)
Shell Chemical Co., NY (p)
Spaulding Fibre Co., Inc., NY (bb,cc, dd,ee)
Specialty Resins Co., Calif (x,y)
Strick Plastics Co., Pa (u,cc)
Sun Chemical Corp., Electro Technical Div., NJ (x)
Swedlow, Inc., Calif (cc)
Synthane Corp., Pa (bb,cc,dd,ee)
Taylor Fibre Co., Pa (bb,cc,dd,ee)
Union Carbide Plastics Co., Div. of Union Carbide Corp., NY
(p,x)—Ad p 257
U.S. Gypsum Co., Ill (x)
U.S. Polymeric Chemicals, Inc., Conn (s)
Waldman, Joseph & Sons, Epoxy Products Div., NJ
(x,y,cc)—Ad p 499
Williamson Adhesives, Inc., Ill (x)

Ethyl Cellulose

Ace Plastic Co., NY (bb,cc,dd,ee)
Adhesive Products Corp., NY (x)
American Hard Rubber Co., Div. of Amerace Corp., NJ (bb,dd,ee)
American Molding Powder & Chemical Co., NY (y)
American Products Mfg. Co., Inc., La (t)
Anchor Plastics Co., Inc., NY (bb,dd, ee)
Auburn Plastics, Inc., NY (bb,dd,ee)
Bamberger, Claude P., Inc., NJ (y)
Bischoff Chemical Corp., NY (u)
Campco Div., Chicago Molded Products Corp., Ill (t,cc)
Carroll, J.B. Co., Ill (cc)
Coating Products, Inc., NJ (t,cc)
Continental-Diamond Fibre Corp., Del (ee)
Crane Plastics, Inc., Ohio (bb,dd,ee)
CrystalX Corp., Pa (bb,cc,dd,ee)
Davis, Joseph Plastics Co., NJ (t,y, bb,cc,dd,ee)
Denver Plastics, Inc., Colo (u)
Dow Chemical Co., Plastics Div., Mich (p,y,cc)
Dyna-Therm Chemical Corp., Calif (p)
General Plastics Mfg. Co., Wash (bb, cc,dd,ee)
Gering Plastics, Div. of Studebaker-Packard Corp., NJ (y,bb,dd)
Glass Laboratories, NY (bb,dd,ee)
H & R Industries, Pa (bb,cc,dd,ee)
Hercules Powder Co., Inc., Del (p)
Heyden Newport Chemical Corp., American Plastics Corp. Div., NY (bb, cc,dd,ee)
Hydrawlik Co., NJ (bb,dd)
Industrial Plastics Corp., Ind (bb,dd)
K S H Plastics, Inc., Mo (bb,cc,dd)
Lus-Trus Corp., Mich cc)
Muehlstein, H. & Co., Inc., NY (y)
Nixon Nitration Works, NJ (bb,cc)
Omni Products Corp., NY (y,bb,cc)
Perfex Plastics, Inc., Ill (bb,dd,ee)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (x)
Pyramid Plastics, Inc., Ill (bb,dd,ee)
Schwab Plastic Corp., Mich (bb,cc,dd, ee)
Simon Products Co., Ill (t)
Southern Plastics Co., SC (bb,cc,dd,ee)
Sunlites Plastics, Inc., Wis (bb,dd,ee)
Superior Plastics, Inc., Ill (bb,ee)
Western Felt Works, Ill (cc)
World Plastics, NY (bb,cc,dd,ee)

Expanded Metals

Aluminum Co. of America, Pa (a)
Aluminum Specialty Co., Wis (a)
American Metal Products, Inc., Ohio (g)
Atlantic Steel Co., Ga (g)
Avon Tube Div., Higbie Mfg. Co., Mich (g)
Biersach & Niedermeyer Co., Wis (a, b,c,f,g)
Castle, A.M. & Co., Ill (a,g)
Clad-Rex Corp., Ill (a,g)
Colonial Alloys Co., Pa (a)
Designers Metal Corp., Ill (a,b,d,e,f, g,j)
Edgcomb Steel & Aluminum Corp., NJ (a,g)
Ellwood City Iron & Wire Co., Pa (c)
Exmet Corp., NY (a,b,c,d,e,f,g,h,j)
Evans, George Corp., Ill (a)
Flexonics Corp., Ill (g)
Hawkridge Bros. Co., Mass (a)
Haydon Corp., NY (a,g)
Hazledine, E.T. Co., Ind (g)
Houston Blow Pipe & Sheet Metal Works, Tex (g)
Ideal Can Co., Mass (g)
Kees, F.D. Mfg. Co., Neb (g)
Levinson Steel Co., Pa (a,g)
Metal Goods Corp., Mo (g)
North American Cement Co., Designers Metals Div., Ind (a,b,c,f,g,j)
Penn Metal Co., Inc., Mass (a,b,c,d, f,g,h,j)
Republic Steel Corp., Ohio (g)
Reynolds Aluminum Supply Co., Ga (a, g)
Rockwell Engineering Co., Ill (a,b,c,g)
Rolled Alloys, Inc., Mich (f)
Rolock Inc., Conn (f)
Ryerson, Joseph T. & Son, Inc., Ill (a,g)
Standard Metals Corp., Mass (f)
Trenton Pipe Nickel Co., NJ b,g)
Trojan Steel Co., W. Va (g)
U.S. Gypsum Co., Ill (a,g)
Vulcan Rail & Construction Co., NY (g)
Ward, H.H. Co., Pa (g)
Wheeling Corrugating Co., W.Va
Wheeling Steel Corp., W.Va (g)
Whitehead Metal Products Co., Inc., NY (a,f)
Whyte, Oliver Co., Inc., NY (a,g)
Wire & Iron Products, Inc., Mich (f,g)

Extrusions

(see below; also Impact Extrusions; Tubing)

Extrusions, Metallic

(excl. Tubing, Pipe)

Accurate Metal Weather Strip Co., Inc., NY (a,b)
Adams Engineering Co., Inc., Fla (a)
Aerolite Extrusion Co., Ohio (a)
Allegheny Ludlum Steel Corp., Pa (g)
Aluminum Co. of America, Pa (a,e)
Aluminum Billets, Inc., Ohio (a)
Aluminum Extrusions, Inc., Mich (a)
American Brass Co., Sub. of Anaconda Co., NY (b)
American Machine & Foundry Co., Cleveland Welding Div., Ohio (g,h)
American Reed Co., Inc., Mass (e)
Ampco Metal, Inc., Wis (b)
Anaconda Aluminum Co., Sub. of Anaconda Co., Ky (a)
Armco Steel Corp., Sheffield Div., Mo (g)
Arvin Industries, Inc., Ind (a)
Atlantic India Rubber Works, Inc., Ill (m)
Atlantic Steel Co., Ga (a)
Auld, D.L. Co., Ohio (a)
B & T Metals Co., Ohio (a)
Babcock & Wilcox Co., Tubular Products Div., Pa (g)
Badger Aluminum Extrusions, NY (a)
Beck, I. & Sons, Inc., NY (a,b)
Belmont Aluminum Extrusion Co., Pa (a)
Benada Aluminum Products Co., Ohio (a)
Beryllium Corp., Pa (b)
Bohn Aluminum & Brass Corp., Mich (a,b)
Bonnell, William L. Co., Inc., Ga (a)
Bridgeport Brass Co., Conn
(a,b,h)—Ad p 176
Brinkerhoff Brass & Bronze Works, Inc., NY (a,b)
Bristol Brass Corp., Conn (b)
Bunker Hill Co., Calif (d)
Burgess-Norton Mfg. Co., Ill (c)
Cameron Iron Works, Inc., Special Products Div., Tex (c,f,g,h)
Capitol Products Corp., Pa (a)
Castle, A.M. & Co., Ill (a)
Chase Brass & Copper Co., Sub. of Kennecott Copper Corp., Conn (a,b,f)
Clendenin Bros., Inc., Md (a,b)
Colonial Alloys Co., Pa (a)
Columbia-Geneva Steel Div., U.S. Steel Corp., Calif (g)
Columbus Bolt & Forging Co., Ohio (a,b,g)
Consolidated Fruit Jar Co., NJ (d)
Copper & Brass Sales, Inc., Mich (a, b,e)
Corson Industries, Pa (a)
Craft Mfg. Co., Ill (a,b,c,e,f,g,h,j)
Crane Plastics, Inc., Ohio (k,m)
Crown Metal Co., Wis (d)
Curtiss-Wright Corp., Metals Processing Div., NY (f,g,h)
Cyril Bath Co., Ohio (a,h)
Detroit Gasket & Mfg. Co., Extruded Metals Div., Mich (a)
Division Lead Co., Ill (d)
Dixie Aluminum Corp., Ga (a)
Dixie Bronze Co., Ala (b)
Doehler-Jarvis Div., National Lead Co., Ohio (a)
Dow Chemical Co., Dow Metal Products Co. Div., Mich
(e)—Ad pp 408-409
Dresser Mfg. Div., Dresser Industries, Inc., Pa (f,g)
Empire Metal Co., NY (d)
Etched Products Corp., NY (a)
Eureka Electric Products Co., Pa (b)
Fletcher Enamel Co., W. Va (a,b,c,d, e,t)
Flynn, Michael Mfg. Co., Pa (a)
Frasse, Peter A. & Co., Inc., NY (g)
Fromson Orban Co., Inc., NY (a)
Fuller, W.P. & Co., Calif (j)
Garlock Packing Co., NY (k,m)
General Extrusions, Inc., Ohio
(a)—Ad p 462
Harper, H. M. Co., Ill (a,b,f,g,h)
Harvey Aluminum, Calif (a,g,h)
Hawkridge Bros. Co., Mass (a)
Himmel Bros. Co., Conn (a)
Hunter Douglas Aluminum Div., Bridgeport Brass Co., Calif (a,b)
International Nickel Co., Inc., NY (f)
Jarl Extrusions, Inc., NY
(a)—Ad p 442
Jasco Aluminum Products Co., NY (a)

Jet Specialties Co., Inc., Calif (k)
Jones & Laughlin Steel Corp., Pa (g)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Kassel Export Co., Inc., NJ (g)
Kawneer Co., Mich (a)
Kelsey-Hayes Co., Mich (g)
Kroh Wagner, Ill (a)
Langsenkamp, F.H. Co., Ind (a)
Light Metals Corp., Mich (a)
Magnode Products, Inc., Ohio (a,e)
Metal Goods Corp., Mo (a)
Metal Trims, Inc., Miss (a)
Moczik Tool & Die Works, Mich (a,b)
Monarch Tool & Mfg. Co., Ky (a)
Mueller Brass Co., Mich (a,b)
National Aluminum Co., Ohio (a)
National Lead Co., NY (a,b,d)
National Metal Products Co., Pa (a,b)
National Tube Div., U.S. Steel Corp., Pa (g)
New Jersey Aluminum Extrusion Co., Inc., NJ (a)
Nuclear Metals, Inc., Mass (a,b,c,e, f,g,h)
Olin Mathieson Chemical Corp., Metals Div., NY (a)
Parish Pressed Steel Div., Dana Corp., Pa (g)
Penn Brass & Copper Co., Pa (a)
Penn Extrusion Corp., Pa (a)
Pfister Tubing Corp., NJ (a)
Phelps Dodge Copper Products Corp., NY
Pioneer Aluminum, Inc., Calif (a)
Pittsburgh Plate Glass Co., Pa (a,g)

Precision Extrusions, Inc., Ill
(a)—Ad p 458

Raybestos-Manhattan, Inc., NJ (k,m)
Republic Metals Co., Inc., NY (d)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY (a, b)
Reynolds Aluminum Supply Co., Ga (a)
Reynolds Metals Co., Va (a)
Rockwell Engineering Co., Ill (a,b,c,g)
Royce Aluminum Corp., Mass (a)
Ryerson, Joseph T. & Son, Inc., Ill (a,g)
Saramar Aluminum Co., Ohio (a)
Scaife Co., Pa (b,c,f,g)
Scovill Mfg. Co., Conn (b)
Serrick Corp., John Lees Div., Ind (a,g)
Southern Aluminum Finishing Co. Inc., Ga (a)
Southern Extrusions, Inc., Ark (a)
Stainless Metals, Inc., NY (g)
Steel Industries, Inc., Ind (b,g)
Superior Industries, Inc., Ohio (a)
Supplex Co., Div. of Amerace Corp., NJ (k)
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (g)
Texas Aluminum Co., Inc., Tex (a)
Textron Metals Co., Ohio (a)
Thompson Products, Inc., Light Metals Div., Ohio (a)
Thompson Products, Inc., Valve Div., Ohio (f,g)
Titan Metal Mfg. Co., Pa (b)
Titanium Metals Corp. of America, NY (h)
Toledo Stamping & Mfg. Co., Ohio (a,g)
Trim Alloys, Inc., Mass (a)
Union Steel Corp., NJ (g)
United Shoe Machinery Corp., Mass (f,g)
U.S. Extrusions Corp., NY (a)
U.S. Steel Corp., Pa (g)
U.S. Steel Supply Div., U.S. Steel Corp., Ill (g)
Universal Converting Corp., Mass (a)
Uniworld Research Corp. of America, Ohio (c)
Vulcan Metal Products, Inc., Ala (a)
Vulcan Rail & Construction Co., NY (a)
Vulcan-Kidd Steel Div., H.K. Porter Co., Inc., Pa (g)
W.F. Mfg. Co., Calif (a)
Warner Mfg. Corp., NJ (a)

Werner, R.D. Co., Pa
(a)—Ad p 437

Wesbar Stamping Corp., Wis (a,b,c,g)
White Metal Rolling & Stamping Corp., NY (a,e)
Whitehead Metal Products Co., Inc., NY (a)
Wolverine Tube Div., Calumet & Hecla, Inc., Mich (a)
Worcester Pressed Steel Co., Mass (a, g)
Youngstown Mfg., Inc., Ohio (a)

Extrusions, Nonmetallic

(excl. Tubing, Pipe)

Ace Plastic Co., NY (k)
Allegheny Plastics, Inc., Pa (k)
Allied Resinous Products, Inc., Ohio (k)
Amco Plastic Pipe Co., Calif (k)
American Agile Corp., Ohio (k)
American Hard Rubber Co., Div. of Amerace Corp., NJ (k,l,m)
American Molding Co., Calif (k)
American Plastics Corp., NY (k)
Anchor Plastics Co., Inc., NY (k)
Anesite Co., Ill (l)
Atlas Mineral Products Co., Pa (k)

Auburn Mfg. Co., Conn
(k,m)—Ad p 450

Auburn Plastics, Inc., NY (k,m)
Automotive Rubber Co., Inc., Mich (m)
Beck, I. & Sons, Inc., NY (m)
Bond International, Inc., Mich (m)
Borden Co., Borden Chemical Div., NY (k)
Bowling Green Rubber Co., Ohio (m)
Brown Rubber Co., Inc., Ind (m)
Button Corp. of America, NJ (k)
Byers, A.M. Co., Pa (k)
Cadillac Plastic & Chemical Co., Mich (k)
Cambridge-Panelyte Molded Plastics Co., Div. of St. Regis Paper Co., Ohio (k)
Campco Div., Chicago Molded Products Corp., Ill (k)
Canfield, H.O. Co., va
Carlon Products Corp., Ohio (k)
Carolina Industrial Plastics Div., Essex Wire Corp., NC (k)
Celluplastic Corp., NJ (k)
Chardon Rubber Co., Ohio (k)
Colonial Plastics Mfg. Co., Div. of Van Dorn Iron Works Co., Ohio (k)

Conneaut Rubber & Plastics Co., Div. of U.S. Stoneware Co., Ohio
(k,m)—Ad p 447

Connecticut Hard Rubber Co., Conn (m)
Continental Rubber Works, Pa (m)
Contour Extrusion Co., NY (k)

Crane Plastics, Inc., Ohio
(k,m)—Ad p 464

Crescent Plastics, Inc., Ind (k)
Davis, Joseph Plastics Co., NJ (k)
Detroit Macold Corp., Mich (k,m)
Dryden Rubber Div., Sheller Mfg. Co., Ill (m)
Eclipse Plastic Industries, Inc., Fla (k)
Electric Autolite Co., Ohio (k)
Eljay Corp., Md (l)
Enflo Corp., NJ (l)
Extruders, Inc., Calif (k)
Faultless Rubber Co., Ohio (m)
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass (m)
Frost Rubber Co., Ill (m)
Fry Plastics International, Calif (k)
Galigher Co., Utah (k)
Garlock Packing Co., NY (k,m)
Geauga Industries Co., Ohio (k,m)
General American Transportation Corp., Ill (k)
General American Transportation Corp., Plastics Div., Ill (k)
General Electric Co., Chemical & Metallurgical Div., Ill (k)
General Gasket, Inc., Conn (m)
General Plastics Corp., Ind (k)
Gering Plastics, Div. of Studebaker-Packard Corp., NJ (k)
Gilman Bros. Co., Conn (k)
Glass Laboratories, Inc., NY (k)
Glass Reinforced Plastics Corp., Ohio (l)
Glastic Corp., Ohio (l)
Goodrich, B.F. Industrial Products Co., Ohio (k)
Gossett and Hill Co., Ill (k)
Gotham Plastics Corp., NY (k)
H & R Industries, Pa (k,m)
Hall Mfg. Co., NJ (k)
Hartwell, H.N. & Sons, Inc., Mass (k)
Haveg Industries, Inc., Del (l)
Hawkeye Rubber Mfg. Co., Iowa (m)
Hitemp Wires, Inc., NY (k)
Hungerford Plastics Corp., NJ (k,m)
Hydrawlik Co., NJ (k,m)
Industrial Plastics Corp., Ind (k)
Industrial Products Div., General Tire & Rubber Co., Ind (k)
Insulation Mfrs. Corp., Ill (k)
Irvington Varnish & Insulation Div., Minnesota Mining & Mfg. Co., NJ (k)
Jet Specialties Co., Inc., Calif (k)
Johnson Plastic Corp., Ohio (k,m)
Johnson Rubber Co., Ohio (m)
Jordan-Rogers Co., Calif (k)
Joymont Plastics, Inc., Ohio (k)
Judsen Rubber Works, Inc., Ill (m)
K S H Plastics, Inc., Mo (k)
Kaykor Industries, Inc., NJ (k)
Keystone Plastics, Inc., NJ (k)
Kraloy Plastic Pipe Co., Inc., Calif (k)
Lavelle Rubber Co., Ill (m)
Luminous Resins, Inc., Ill (k)
Lus-Trus Corp., Mich (k)
Luzerne Rubber Co., NJ (k,l)
Madin Plastics Inc., NJ (k)
Maloney, F.H. Co., Tex (k,m)
Martin Rubber Co., Inc., NJ (m)
Mayon Plastics, Minn (k)
Mechanical Rubber Products Co., NY (l)
Meyer, J. & Sons, Inc., Pa (k)
Mid-States Rubber Products, Inc., Ind (m)
Midwest Plastic Products Co., Ill (k)
Minnesota Rubber Co., Minn (m)
Minnesota Rubber & Gasket Co., Minn (m)
Moldex, NY (m)
Moore, Samuel & Co., Ohio (k)

Moxness Products, Inc., Wis
(m)—Ad p 460

Mueller Brass Co., Mich
(k)—Ad p 455

Multiple Extrusions, Inc., Minn (m)
Munray Products Div., Fanner Mfg. Co., Ohio (k)
National Gasket & Washer Mfg. Co., Inc., NY (k,l,m)
National Lock Co., Ill (k)
National Vulcanized Fibre Co., Del (k)
New England Tape Co., Div. of United-Carr Fastener Corp., Mass (k)
Panelyte Div., St. Regis Paper Co., NJ (k)
Parker, Stearns & Co., Inc., NY (m)
Pawling Rubber Corp., NY (k,l)
Pennsylvania Fluorocarbon Co., Inc., Pa (k)
Perfex Plastics, Inc., Ill (k,m)
Pipco International Corp., Sub. of Plastiglide Mfg. Corp., Calif (k)
Plastex Co., Ohio (k)
Plastic Engineering, Inc., Ohio (k)
Plastic Packaging Co., Ill (k)
Plastiglide Mfg. Corp., Calif (k)
Plymouth Cordage Co., Mass (k)
Polyform Plastics Corp., NY (k)
Polygon Plastic Co., Ind (l)
Polymer Corp. of Pennsylvania, Sub. of Polymer Corp., Pa (k)
Polyplastic Products, Inc., NJ (k)
Prince Rubber & Plastics Co., Inc., NY (k,l)
Pyramid Plastics, Inc., Ill (k)
Raybestos-Manhattan, Inc., NJ (l,m)
Reliance Plastic & Chemical Corp., NJ (k)
Resistoflex Corp., NJ (k)
Rogers Corp., Conn (m)
Rowland Products, Inc., Conn (k)
Schaefer-Hausner Corp., NY (k)
Schwab Plastic Corp., Mich (k,m)
Seamless Rubber Co., Conn (m)
Shamban, W.S. & Co., Ind (k)
Sheffield Plastics Co., Mass (k)
Sheller Mfg. Corp., Mich (k,l,m)
Sierra Engineering Co., Calif (m)
Southern Plastics Co., SC (k,m)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (k)
Stalwart Rubber Co., Ohio (m)
Standard Products Co., Mich (m)
Stockwell Rubber Co., Inc., Pa (k,m)
Sun Rubber Co., Ohio (m)
Sunlites Plastics, Inc., Wis (k)
Superior Plastics, Inc., Ill (k)
Supplex Co., Div. of American Hard Rubber Co., NJ (k,m)
Taunton Div., Haveg Industries, Inc., Mass (k,m)
Technical Specialties Co., NY (m)
Textron Metals Co., Ohio (k)
Thermoid Div., H.K. Porter Co., Pa (k,m)
Thombert, Inc., Iowa (k)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Tri-Point Mfg. & Developing Co., NY (k)
United Shoe Machinery Corp., Mass (k,m)
U.S. Gasket Plastics Div., Garlock Packing Co., NJ (k,l)
U.S. Rubber Co., Mechanical Goods Div., Ind (k)
U.S. Stoneware Co., Ohio (k,l,m)
Victory Plastics Co., Mass (k)
Vogt Mfg. Co., NY (k)
Vulcanized Rubber & Plastics Co., Pa (m)
Western Felt Works, Ill (l,m)
Western Plastics Corp., Neb (k)
Western Textile Products Co., Mo (k,m)
Westlake Plastics Co., Pa (k)
William Brand-Rex Div., American Enka Corp., Mass (k)
Williams - Bowman Rubber Co., Ill (k,l)—Ad p 276
World Plastics, NY (k)
Yale Rubber Mfg. Co., Mich (m)
Yardley Plastics Co., Ohio (k)—Ad p 466

Fabrics, Nonwoven Synthetic

Albany Felt Co., NY
American Felt Co., Conn —Ad p 312
Beckmann, Inc., NY
Booth Felt Co., Inc., NY
Cadillac Plastic & Chemical Co., Mich
Carborundum Co., Refractories Div., NJ
Chicopee Mills, Inc., NY
Chicopee Mills, Inc., Lumite Div., NY
Continental Felt Co., NY —Ad p 322
Dexter, C.H. & Sons, Inc., Conn
Electrofilm Inc., Calif
Felters Co., Mass —Ad p 310
Ferro Corp., Fiber Glass Div., Tenn
Filpaco Industries, Inc., Ill
Foss Mfg. Co., Id
Gustin-Bacon Mfg. Co., Mo
Kendall Co., Fiber Products Div., Mass
Masland Duraleather Co., Pa
National Felt Co., Mass
Noone Industrial Fabrics Div., Kenwood Mills, NY
Quaker City Felt Co., Pa
Russell Mfg. Co., Conn
Snyder, M.L. & Son, Inc., Pa
Star Woolen Co., NY
Stevens, J.P. & Co., Inc., NY
Tallman-McCluskey Fabrics Co., Mo
Troy Blanket Mills, NY —Ad p 327
U.S. Plywood Corp., NY
Wellington Sears Co., NY
Wood Conversion Co., Minn

Fabrics, Woven

(coated)

Albany Felt Co., NY
Aldan Rubber Co., Pa
Alpha Wire Corp., NY
Andrews-Alderfer Div., Kendall Co., Ohio
Cadillac Plastic & Chemical Co., Mich
Chicago-Allis Mfg. Corp., Ill
Chicopee Mills, Inc., Lumite Div., NY
Connecticut Hard Rubber Co., Conn
Continental-Diamond Fibre Corp., Del
Cordo Chemical Corp., Conn —Ad p 269
du Pont de Nemours, E.I. & Co., Inc., Del —Ad p 315
Fabricon Products Div., Eagle-Picher Co., Mich —Ad p 275
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass
Flexible Tubing Corp., Minn
Foss Mfg. Co., Id
General Asbestos Gasket Mfg. Corp., Mo
General Plastics Corp., NJ
Goodrich, B.F. Industrial Products Co., Ohio
Kaufman Glass Co., Del
Narmco Industries, Inc., Narmco Materials Div., Calif
National Gasket & Washer Mfg. Co., Inc., NY
Prince Rubbber & Plastic Products Co., Inc., NY
Reeves Bros., Inc., Vulcan Rubber Products Div., NY —Ad p 318
Russell Mfg. Co., Conn
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio
Twitchell, E.W., Inc., Pa
Wasco Products, Inc., Mass
Wisconsin Gasket & Mfg. Co., Wis

Fabrics, Woven

(uncoated)

Aetna Felt Co., Inc., NY
Albany Felt Co., NY
Alox Mfg. Co., Mo
Alpha Wire Corp., NY
Atlantic Bag Co., NY
Booth Felt Co., Inc., NY
Cadillac Plastic & Chemical Co., Mich
Chicopee Mills, Inc., Lumite Div., NY
Electrofilm, Inc., Calif
Ferro Corp., Fiber Glass Div., Tenn
Filpaco Industries, Inc., Ill
Foss Mfg. Co., Id
Franklin Cotton Mill Co., Ohio
General Asbestos Gasket Mfg. Corp., Mo
Kendall Co., Fiber Products Div., Mass
National Gasket & Washer Mfg. Co., Inc., NY
Noone Industrial Fabrics Div., Kenwood Mills, NY
Russell Mfg. Co., Conn
Sherwatt Equipment & Mfg. Co., Inc., NY
Stevens, J.P. & Co., Inc., NY
Supreme Industrial Products Co., Ill
Tallman-McCluskey Fabrics Co., Mo
Thompson, H.I. Fiber Glass Co., Calif
Turner Halsey Co., NY
Twitchell, E.W., Inc., Pa
U.S. Rubber Co., NY
U.S. Rubber Co., Textile Div., NY
Vulcan Rubber Products Div., Reeves Bros., Inc., NY
Wellington Sears Co., NY

Fasteners

(see Mechanical Fasteners)

Felts, Synthetic

(see Fabrics, Nonwoven)

Felts, Wool

Aetna Felt Co., Inc., NY
Albany Felt Co., NY
American Felt Co., Conn —Ad p 312
Armstrong Cork Co., Pa
Artex Felt Co., NY
Auburn Mfg. Co., Conn
Bacon Felt Co., Mass
Beckmann, Inc., NY
Booth Felt Co., Inc., NY
Boston Felt Co., Mass
Carey, Philip Mfg. Co., Ohio
Central Felt & Fabrics Corp., NY
Coated Abrasive Products, Inc., Ohio
Continental Felt Co., NY —Ad p 322
Felters Co., Mass —Ad p 310
Fidelity Felt & Mfg. Co., NY
Filpaco Industries, Inc., Ill
General Gasket, Inc., Conn
Hall, C P. Co., NY
Johns-Manville Corp., NY
Mechanical Felt & Textiles Co., NJ
National Felt Co., Mass
National Gasket & Washer Mfg. Co., Inc., NY
Noone Industrial Fabrics Div., Kenwood Mills, NY
Quaker City Felt Co., Pa
Reynolds Aluminum Supply Co., Ga
Standard Asbestos Mfg. Co., Ill
Standard Felt Co., Calif
Supreme Industrial Products Co., Ill
Wellington Sears Co., NY
Western Felt Works, Ill
Wisconsin Gasket & Mfg. Co., Wis
Wood Conversion Co., Minn

Ferrites

(see Ceramics)

Fibers, Synthetic

(see specific polymer)

Filler Metals, Welding

(electrodes, rods, etc.)

Abalon Precision Mfg. Corp., NY
Acme Stamping & Wire Forming Co., Pa
Alloy Rods Co., Pa
All-State Welding Alloys Co., Inc., NY
Alofs Mfg. Co., Mich
American Brass Co., Sub. of Anaconda Co., NY
American Manganese Steel Div., American Brake Shoe Co., Ill
American Products Corp., Ill
Ampco Metal, Inc., Wis
Arcos Corp., Pa
Atlas Foundry Co., Ohio
Bridgeport Brass Co., Conn —Ad p 176
Champion Rivet Co., Ohio
Crucible Steel Co. of America, Pa
Dana Corp., Auburn Div., Ind
Electric Steel Foundry Co., Ore
Electronic Parts Mfg. Co., Inc., NJ
Eutectic Welding Alloys Corp., NY
General Dynamics Corp., Liquid Carbonic Div., Ill
Harnischfeger Corp., Wis
Hayden Wire Works, Inc., Mass
Haynes Stellite Co., Div. of Union Carbide Corp., Ind
Ideal Can Co., Mass
Ingersoll Products Div., Borg-Warner Corp., Ill
International Nickel Co., Inc., NY
Jervis Corp., Mich
Johnson, A. & Co., Inc., NY
K S M Products, Inc., NJ
Kaiser Aluminum & Chemical Sales, Inc., Ill
Lincoln Electric Co., Ohio
Linde Co., Div. of Union Carbide Corp., NY
Lukens Steel Co., Pa
Magnesium Co. of America, Ind
Magnesium Products of Milwaukee, Inc., Wis
Magnesium Elektron, Inc., NY
Manganese Steel Forge Co., Pa
Marquette Mfg. Co., Inc., Minn
McDowell Mfg. Co., Pa
Metal Goods Corp., Mo
Metal & Thermit Corp., NJ
Midwest Stamping & Mfg. Co., Ohio
Morrisville Foundry Co., Inc., Vt
Narragansett Boiler Works, Inc., RI
Noland Tank & Galvanizing Co., Tenn
Page Steel & Wire Div., American Chain & Cable Co., Pa
Rockwell Engineering Co., Ill
Somerset Foundry & Machine Co., Pa
Southern Metal Products Co., La
Titan Metal Mfg. Co., Pa
Victor Equipment Co., Calif
Walmet Alloys Co., Mich —Ad p 82
Wall Colmonoy Corp., Stainless Process Div., Mich
Waterman Industries, Inc., Calif
Wesbar Stamping Corp., Wis
Whitehead Metal Products Co., Inc., NY

Film

(see specific plastic or rubber)

Fluorocarbon Plastics

aaRBee Plastic Co., Calif (y)
Acme Resin Corp., Ill (p)
Allegheny Plastics, Inc., Pa (bb,cc,dd,ee)
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY (y)
Auburn Plastic Engineering, Ill (t,bb,cc,dd,ee)
Automotive Rubber Co., Inc., Mich (y,cc)
Bamberger, Claude P., Inc., NJ (y)
Belding Corticelli Industries, NY (y)
Cadillac Plastic & Chemical Co., Mich (t,bb,cc,dd,ee)
Chemical Coatings and Engineering Co., Inc., Pa (x)
Chicago Gasket Co., Ill (t,bb,cc,dd,ee)
Colonial Kolonite Co., Ill (bb,cc,dd,ee)
Corico Plastics, Inc., NY (bb,cc,dd,ee)
Commercial Plastics & Supply Corp., NY (bb,cc,dd,ee)
Conneaut Rubber and Plastics Co., Div. of U.S. Stoneware Co., Ohio (bb,cc,dd,ee)
Continental-Diamond Fibre Corp., Del (bb,cc,dd,ee)
Cosmo Plastics Co., Ohio (u)
Crane Packing Co., Ill (t,bb,cc,dd,ee)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Curbell, Inc., NY (bb,cc,dd,ee)
Dixon Corp., RI (y,bb,cc,dd,ee)—Ad p 434
Dodge Fibers Corp., NY (s,t,cc,dd)
du Pont de Nemours, E.I. & Co., Inc., Del (p,s,t,y)
Electro Chemical Engineering & Mfg. Co., Pa (t,cc)
Enflo Corp., NJ (t,bb,cc,dd,ee)
Fluorocarbon Co., Calif (p,t,bb,cc,dd,ee)
Fluoro-Plastics, Inc., Div. of Flexrock Co., Pa (bb,cc,dd,ee)
Galigher Co., Utah (bb,cc,dd,ee)
Garlock Packing Co., NY (y,bb,cc,dd,ee)
General Gasket, Inc., Conn (t,cc)
General Plastics Corp., NJ (t,x)
General Plastics Mfg. Co., Wash (bb,cc,dd,ee)
H & R Industries, Pa (bb,cc,dd,ee)
Halogen Insulator & Seal Corp., Ill (bb,cc,dd,ee)
Haveg Industries, Inc., Del (bb,cc,ee)
Hitemp Wires, Inc., NY (ee)
Insulation Mfrs. Corp., Ill (t,bb,cc,dd,ee)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Kurz Kasch, Inc., Ohio (y)
Maloney, F.H. Co., Tex (y)
Minnesota Mining & Mfg. Co., Minn (y)
Minnesota Mining and Mfg. Co., Chemical Div., Minn (p,y)
Norrich Plastics Corp., NY (bb,ee)
Pennsylvania Fluorocarbon Co., Inc., Pa (bb)
Permacel, NJ (t,cc,ee)
Polymer Corp. of Pennsylvania, Sub. of Polymer Corp., Pa (t,bb,cc,dd,ee)—Ad p 230
Prince Rubber & Plastics Co., Inc., NY (bb,cc,ee)
Radiation Applications, Inc., NY (bb,cc,dd,ff)
Raybestos - Manhattan, Inc., Plastics Products Div., Pa (bb,cc,ee)—Ad p 268
Resistoflex Corp., NJ (bb,cc,ee)
Russell Mfg. Co., Conn (s)
Sanford Plastics Corp., NY (bb,ee)

Shamban, W.S. & Co., Calif (p,t,x, y,bb,cc,dd,ee)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (t,y,bb,cc,dd,ee)
Staver Co., Inc., NY (cc,dd)
Thombert, Inc., Iowa (bb,cc,dd,ee)
Tri-Point Mfg. & Developing Co., NY (bb)
U.S. Gasket Plastics Div., Garlock Packing Co., NJ (t,bb,cc,dd,ee)
U.S. Stoneware Co., Ohio (ee)
Vulcan Rubber Products Div., Reeves Bros. Inc., NY (bb,dd,ee)
Westlake Plastics Co., Pa (t,y,bb,cc, dd,ee)

Fluorocarbon Rubber

(fluoroelastomers)

Automotive Rubber Co., Inc., Mich (cc,dd)
Belko Corp., Md (y)
Bond International, Inc., Mich (y,ee)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chemical Coatings and Engineering Co., Pa (x,y)
Chicago-Allis Mfg. Corp., Ill (p)
Colonial Rubber Co., Div. of U.S. Stoneware Co., Ohio (y,cc,dd)—Ad p 441
Connecticut Hard Rubber Co., Conn (cc,dd)
Continental Rubber Works, Pa (bb,cc, dd,ee)
Dayton Rubber Co., Ohio (y,bb,cc,dd,ee)
Dodge Fibers Corp., NY (s,t,cc,dd)
Dow Corning Corp., Mich (p)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
du Pont de Nemours, E.I. & Co., Inc., Del (cc)
Electro Chemical Engineering & Mfg. Co., Pa (t,cc)
Flexible Tubing Corp., Conn (ee)
Garlock Packing Co., NY (y,cc)
Hitemp Wires, Inc., NY (ee)
Hooker Chemical Corp., NY (p)
Johns-Manville Corp., Dutch Brand Div. NY (cc)
Maloney, F.H. Co., Tex (y)
Minnesota Mining & Mfg. Co., Minn (p)
Minnesota Mining and Mfg. Co., Chemical Div., Minn (p,y)
Moxness Products, Inc., Wis (cc)—Ad p 460
Norrich Plastics Corp., NY (bb,dd,ee)
Parker Seal Co., Div. of Parker-Hannifin Corp., Calif (u)
Rogers Corp., Conn (u,y)—Ad p 261
Russell Mfg Co., Conn (s)
Trostel, Albert Packing, Ltd., Wis (y)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (p,y,cc)
Western Felt Co., Ill (y,cc,dd,ee)
Westlake Plastics Co., Pa (bb,cc,dd)

Foams

(see specific plastic or rubber)

Foil

(see specific metal)

Forgings

(see also Cold Headed Parts)

Abegg & Reinhold Co., Calif (g)
Accurate Brass Corp., NY (b)
Albert Pipe Supply Co., Inc., NY (c,g)
Alco Products, Inc., NY (g)
Allegheny Ludlum Steel Corp., Pa (g)
Aluminium Ltd. Sales, Inc., NY (a)
Aluminum Co. of America, Pa (a,e)—Ad pp 423-424
Amalgamated Steel Corp., Ohio (g)
American Brass Co., Sub. of Anaconda Co., NY (b)
American Car & Foundry Div., ACF Industries, Inc., NY (g)
American Chain & Cable Co., Pa (g)
American Forge & Mfg. Co., Pa (g)
American Manganese Bronze Co., Pa (b)
American Metal Products Co., Mich (a,g)
American Steel Foundries, Ill (g)
Amforge Div., American Brake Shoe Co., Ill (a,g)
Ampco Metal, Inc., Wis (b)
Anti-Corrosive Metal Products Co., Inc., NY (g)
Armco Steel Corp., Sheffield Div., Mo (g)
Atlas Drop Forge Co., Mich (f,g,h)
Auld, D.L. Co., Ohio (a)
Avins Industrial Products Corp., NY (b)
Baldt Anchor, Chain & Forge Div., Boston Metals Co., Pa (a,b,g)
Baldwin-Lima-Hamilton Corp., Pa (g,h)
Bay City Forge Co., Pa (g)
Bethlehem Steel Co., Pa (g)
Billings & Spencer Co., Conn (a,b,g,h)
Bingham Herbrand Corp., Herbrand Div., Ohio (g)
Blakeslee Forging Co., Conn (a,b,c,d, f,g,h)
Bohn Aluminum & Brass Corp., Mich (a,b)
Braeburn Alloy Steel Corp., Pa (g)
Brewer-Titchener Corp., NY (a,g)
Bridgeport Brass Co., Conn (a,b,f)—Ad p 176
Bristol Brass Corp., Conn (b)
California Drop Forge Co., Calif (g,h)
Cameron Iron Works, Inc., Special Products Div., Tex (c,f,g,h)—Ad p 439
Canton Forge & Axle Works, Poor & Co., Ohio (f,g)
Carbo Tool & Die Co., Ohio (c,f)
Carpenter Steel Co., Pa (g)
Champion Rivet Co., Ohio (b,c,g)
Chase Brass & Copper Co., Sub. of Kennecott Copper Corp., Conn (a,b)
Chicago Extruded Metals Co., Ill (b)
Cincinnati Forging Co., Ohio (b)
Clapp, E.D. Mfg. Co., Inc., NY (b,c, f,g)
Cleveland Cap Screw Co., Ohio (a,b, f,g,h)
Cleveland City Forge Co., Ohio (a, c,f,g,h)
Colonial Steel Div., Vanadium-Alloys Steel Co., Pa (g)
Columbia-Geneva Steel Div., U.S. Steel Corp., Calif (g)
Columbus Bolt & Forging Co., Ohio (g)
Commercial Shearing & Stamping Co., Ohio (g)
Composite Forgings, Inc., Mich (g)
Consolidated Industries Inc., Conn (a, b,e,f,g,h)
Copper & Brass Sales, Inc., Mich (a,b)
Cored Forging Div., Bridgeport Brass Co., Conn (a,b)
Crucible Steel Co. of America, Pa (c,f,g)
Crucible Steel Co. of America, Titanium and Vacuum Metals Product Div., Pa (b,c,f,g,h)
Curtiss-Wright Corp., Metals Processing Div., NY (a,b,f,g)
Custom Tool and Mfg. Co., Minn (c,f, g,h)
Cyril Bath Co., Ohio (a,g)
Dirilyte Co. of America, Inc., Ind (a,b,e)
Doehler-Jarvis Div., National Lead Co., Ohio (a)
Edgcomb Steel & Aluminum Corp., NJ (g)
Edgewater Steel Co., Pa (g,h)
Electric Autolite Co., Ohio (c)
Electric Materials Co., Pa (b)
Electric Steel Foundry Co., Ore (f,g)
Endicott Forging & Mfg. Co., Inc., NY (b,f,g,h)
Eureka Electric Products Co., Pa (a, b,g)
Fairmount Tool & Forging, Inc., Sub. of Houdaille Industries, Inc., Ohio (g)
Finkl, A. & Sons Co., Ill (g)
Frasse, Peter A. & Co., Inc., NY (a,g)
Fromson Orban Co., Inc., NY (a)
Garden State Forge Co., NJ (a,b,c,f, g,h)
General Drop Forge Corp., NY (g)
Giant Grip Mfg. Co., Wis (a,g,h)
Greene, G.G. Corp., Pa (g)
Harrisburg Steel Co., NY (g)
Harvey Aluminum, Calif (a,e,g)
Heppenstall Co., Pa (g,h)
Hobbs, Clinton E. Co., Mass (c,g)
Hunter-Douglas Aluminum Div., Bridgeport Brass Co., Calif (a,b)
Huron Forge & Machine Co., Mich (a,b,g)
Illinois Forge, Inc., Ill (g)
Illinois Iron & Bolt Co., Ill (g)
Indiana Forge & Machine Co., Ind (g)
Interstate Drop Forge Co., Wis (f,g)
Irwin-Sensenich Corp., Pa (g)
Isaacson Iron Works, Wash (g)
Janney Cylinder Co., Pa (b)
Jessop Steel Co., Pa (g)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)—Ad p 419
Kelsey-Hayes Co., Mich (g,h)
Keystone Forging Co., Pa (g)
Kovar, John R. Mfg. Co., Inc., Minn (g)
Kropp Forge Co., Ill (g,h)
Ladish Co., Wis (a,b,c,e,f,g,h)
Larson, Charles E. & Sons, Inc., Ill (a,b,c,g)
Larson Tool & Stamping Co., Mass (a,b,c,e,f,g,h,j)
Latrobe Steel Co., Pa (g)
Lenape Hydraulic Pressing & Forging Co., Pa (a,b,g)—Ad p 462
Lindell Drop Forge Co., Mich (g)
Machinery Forging Co., Ohio (g)
Mallory, P.R. & Co., Inc., Ind (b)
Manganese Steel Forge Co., Pa (g)
McCarter Iron Works, Inc., Pa (g)
McInnes Steel Co., Pa (f,g,h)
McNally Pittsburg Mfg. Co., Kan (g)
Melling Forging Co., Mich (f)
Midvale-Heppenstall Co., Pa (c,f,g)
Milwaukee Forge & Machine Co., Wis (g)
Montague Machine Co., Mass (g)
Moore Dry Dock Co., Calif (g)
Mueller Brass Co., Mich (a,b)—Ad p 455
Murray, A.B. Co., Inc., NJ (a,b,f,g)
Murray Tube Works, Inc., NJ (a,b,g)
National Forge & Ordnance Co., Pa (g)
National Lead Co., NY (a,b,h)
National Supply Co., Pa (g)
National Tube Div., U.S. Steel Corp., Pa, (g)
Norcross, C.S. & Sons Co., Ill (g)
Ohio Forge & Machine Corp., Ohio (c,f,g)
Olderman Mfg. Corp., Conn (b)
Olds Alloys Co., Calif (b)
Pacific States Steel Corp., Calif (g)
Park Drop Forge Co., Ohio (g)
Pattin Mfg. Co., Ohio (g)
Pencoyd Steel & Forge Corp., Pa (c,g)
Peninsular Steel Co., Mich (g)
Pettibone Mulliken Corp., Ill (g)
Philadelphia Bronze & Brass Corp., Pa (a,b,f,h)
Phoenix Mfg. Co., Ill (g)
Pittsburgh Forgings Co., Pa (a,f,g)
Porter, H.K., Inc., Mass (g)
Porter, H.K., Inc., Forge & Fittings Div., Ohio (a,g)
Rankin Forge Co., Pa (c,g)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY (a,b)
Rhode Island Tool Co., RI (a,b,c,f,g)—Ad p 450
Rockford Bolt & Steel Co., Ill (g)
Rockwell Engineering Co., Ill (a,b,c,g)
Rome Mfg. Div., Revere Copper & Brass, Inc., NY (a,b)
Ryerson, Joseph T. & Son, Inc., Ill (a,g)
St. Pierre Chain Corp., Mass (a,f,g)
Scovill Mfg. Co., Mill Products Div., Conn (a,b)
Seltzer, George H. & Co., Pa (g)
Sherman & Reilly, Inc., Tenn (a,g)
Skookum Co., Inc., Ore (g)
Smith-Armstrong Forge, Inc., Ohio (g)
Standard Forge & Axle Co., Inc., Ala (g)
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa (g)
Star Heel Plate Co., Inc., NJ (g)
Steel, R. & Sons, Inc., NY (f,g)
Steel Improvement and Forge Co., Ohio (a,g)
Struthers Wells Corp., NY (f,g)
Taylor Forge & Pipe Works, Ill (a,c, f,g,h)
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (g)
Thompson Products, Inc., Valve Div., Ohio (f,g)
Titan Metal Mfg. Co., Pa (a,b)
Tool & Mfg. Co., Inc., Pa (g)
Transue & Williams Steel Forging Corp., Ohio (b,c,f,g,h)
Tube Turns, Div. of Chemetron Corp., Ky (a,b,c,e,f,g,h)
Union Forging Co., NY (g)
United Forge Co., Mich (c,g)
United Shoe Machinery Corp., Mass (a)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

U.S. Steel Corp., Pa (g)
Universal-Cyclops Steel Corp., Pa (f,g
Uniworld Research Corp. of America Ohio (c)
Vanadium-Alloys Steel Co., Pa (g)
Vulcan-Kidd Steel Div., H.K. Porter Co., Inc., Pa (g)
Walker Forge, Inc., Wis (g)
Weatherhead Co., Ind (a,b,g,h)
Weber-Knapp Co., NY (a)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (a,b,c,f,g,h)
Wilcox Forging Corp., Pa. (e,f,g,h)
Wilde Drop Forge & Tool Co., Inc., Mo (g)
Wilde Tool Co., Inc., Kan (g)
Williams, J.H. & Co., NY (a,b,e,f,g,h)
Wyman-Gordon Co., Mass (a,e,f,g,h)
Zeller Corp., Ohio (g)
Ziv Steel & Wire Co., Ill (g)

Forsterite

(see Ceramics)

Furanes

Adhesive Products Corp., NY (x)
Alcylite Plastics & Chemical Corp., Calif (p)
Atlas Mineral Products Co., Pa (p,x)
Durez Plastics Div., Hooker Chemical Corp., NY (p)
Electro Chemical Engineering & Mfg. Co., Pa (cc)
Foss Mfg. Co., Id (x)
Furane Plastics, Inc., Calif (p,x)
Haveg Industries, Inc., Del (p,bb,cc,ee)
Knight, Maurice A., Ohio (p,x)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (x)
Reichhold Chemicals, Inc., NY (p)
U.S. Stoneware Co., Ohio (y)

Galvanized Metals

(see Precoated Metals)

Galvanizers

Acme Galvanizing Co., Calif
Advance Galvanizing Co., Calif
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich
American Smelting & Refining Co., NY
American Tinning & Galvanizing Co., Pa
Armco Steel Corp., Ohio
Armor Galvanizing Works, Inc., Calif
Atlantic Steel Co., Ga
Atlas Galvanizing Co., Calif
Bessemer Galvanizing Works, Ala
Bethlehem Steel Co., Pa
Boyles Galvanizing & Plating Co., Tex
Buffalo Steel Corp., NY
Byers, A.M. Co., Pa
Clayton & Lambert Mfg. Co., Ky
Clifton Conduit Corp., Md
Columbian Steel Tank Co., Mo
Continental-Emsco Co., Calif
Debevoise Co., NY
Designers Metal Corp., Ill
Detroit Brass & Malleable Co., Mich
Dow Chemical Co., Tex
Empire Metal Co., NY
Enterprise Galvanizing Co., Pa
Fanner Mfg. Co., Ohio
Farrelloy Co., Pa
Fenestra, Inc., Mich
General Chain & Mfg. Corp., Ohio
Green-Walker Galvanizing Co., Inc., La
Gregory, Thomas Galvanizing Works, NY
Hanlon-Gregory Galvanizing Co., Pa
Haywilk Galvanizing, Inc., La
Hill, James Mfg. Co., RI
Illinois Edison Porcelain Div., McGraw-Edison Co., Ill
Independent Galvanizing Co., NJ
Joslyn Mfg. & Supply Co., Ill
Joslyn Pacific Co., Calif
Kent County Galvanizing Co., RI
Kinkead Industries, Inc., Ill
Kobel, W.R. Sheet Metal Products, Utah
Koven, L.O. & Bro., Inc., NJ
Lawson, F.H. Co., Ohio
Lehigh Structural Steel Co., Pa
Lewis Bolt & Nut Co., Minn
Line Material Industries, McGraw-Edison Co., Pa
Los Angeles Galvanizing Co., Calif
Malleable Iron Fittings Co., Conn
Maze, W.H. Co., Ill
Metal Coating Corp., Ill
Metallizing Co. of Los Angeles, Inc., Calif
Metalplate Co., Inc., Ala
Missouri Rolling Mill Corp., Miss
National Galvanizing Co., Pa
National Gasket & Washer Mfg. Co., Inc., NY
New Jersey Zinc Co., NY
Noland Tank & Galvanizing Co,, Tenn
Northwestern Steel & Wire Co., Ill
Nowery J. Smith Bolt & Supply Co., Tex
Nylok Corp., NJ
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa
Penn Metal Co., Inc., W.Va
Pittsburgh Steel Co., Pa
Pratt, William E. Foundry Div., Joslyn Mfg. & Supply Co., Ill
Promat Div., Poor & Co., Ill
Reed & Prince Mfg. Co., Mass
Republic Steel Corp., Ohio
Riverside Foundry & Galvanizing Co., Mich
Roebling's, John A. Sons Div., Colorado Fuel & Iron Corp., NJ
Rohnco, Inc., Ill
Ryerson, Joseph T. & Son, Inc., Ill
San Francisco Galvanizing Works, Calif
Sawhill Tubular Products, Inc., Pa
Scaife Co., Pa
Schlueter Mfg. Co., Mo
Sealube Co., Mass
Sharon Steel Corp., Pa
Sherman & Reilly, Inc., Tenn
Smith, N.J. Bolt Co., Tex
Southern Galvanizing Co., Md
Southern Metal Products Co., La
Spencer Nahm Co., Calif
Spring City Foundry Co., Pa
Stevens, Frederic B., Inc., Mich
Superior-Pacific Galvanizing Co., Calif
Trenton Pipe Nipple Co., NJ
WLS Stamping Co., Ohio
Wessels Co., Mich
Wilcox-Crittenden Div., North & Judd Mfg. Co., Conn
Witt Cornice Co., Galvanizing Div., Ohio
Wood, John Co., Ill
Worcester Wire Works Div., National-Standard Co., Mass
Young & Greenawalt, Ind

Germanium

African Metals Corp., NY (w)
American Metal Climax, Inc., NY (o,w,aa)
American Zinc Sales Co., Mo (q)
Belmont Smelting & Refining Works, Inc., NY (aa)
Eagle-Picher Co., Ohio (w,aa)
Hardy, Charles, Inc., NY (aa)
New Jersey Metals Co., NJ (o)
Parker Metal Goods Co., Mass (bb)
Sylvania Electric Products, Inc., Chemical & Metallurgical Div., Pa (w)
Ullmann, Inc., Wis (o,ee)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)

Glass, Alumino-Silicate

Bassichis Co., Ohio (aa)
Bausch & Lomb Optical Co., NY (r)
Bird, Richard H. Co. Inc., Mass (r)
Corning Glass Works, NY (r,aa,bb,ee)—Ad p 319
Fischer & Porter Co., Pa (r)
Kaufman Glass Co., Del (z,bb,cc,ee)
Kimble Glass Co., Sub. of Owens-Illinois Glass Co., Ohio (r,aa,bb,ee)
Kopp Glass, Inc., Pa (r)—Ad p 309
Lancaster Glass Corp., Ohio (r)
Pittsburgh Plate Glass Co., Pa (s)
Russell Mfg. Co., Conn (r,s)

Glass, Borosilicate

Anchor Hocking Glass Corp., Ohio (r)
Applied Instruments, Inc., NY (z,bb,cc,ee)
Bassichis Co., Ohio (aa)
Bausch & Lomb Optical Co., NY (r)
Bird, Richard H. Co., Mass (r)
Corning Glass Works, NY (r,z,aa,bb,cc,ee)—Ad p 319
Fischer & Porter Co., Pa (r)
Fish-Schurman Corp., NY (r)
Friedrich & Dimmock, Inc., NJ (r,s)
Gustin-Bacon Mfg. Co., Mo (r,s)
Johns-Manville Corp., NY (s)
Kaufman Glass Co., Del (z,bb,cc,ee)
Kimble Glass Co., Sub. of Owens-Illinois Glass Co., Ohio (r,aa,bb,ee)
Kopp Glass, Inc., Pa (r)—Ad p 309
Lancaster Glass Corp., Ohio (r)
Mansol Ceramics Co., NJ (r,aa)
Marsco Mfg. Co., Ill (r)
Modiglass Fibers, Inc., NJ (s)
Penberthy Instrument Co., Wash (r)
Pittsburgh Corning Corp., Pa (u)
Pittsburgh Plate Glass Co., Pa (s)
Pittsburgh Plate Glass Co., Fiber Glass Div., Pa (s)
Russell Mfg. Co., Conn (s)
Semon Bache & Co., NY (z,cc,ee)
Shull Bros. Glass Co., NJ (r,ee)
Thompson, H.I. Fiber Glass Co., Calif (s)

Glass, Lead Alkali Silicate

Bassichis Co., Ohio (aa)
Bausch & Lamb Optical Co., NY (r)
Corning Glass Works, NY (r,aa,bb,ee)—Ad p 319
Fischer & Porter Co., Pa (r)
Kaufman Glass Co., Del (z,bb,cc,ee)
Kimble Glass Co., Sub. of Owens-Illinois Glass Co., Ohio (r,aa,bb,ee)
Kopp Glass, Inc., Pa (r)—Ad p 309
Lancaster Glass Corp., Ohio (r)
Mansol Ceramics Co., NJ (r,aa)
Pemberthy Instrument Co., Wash (r,z)
Semon Bache & Co., NY (z,cc,ee)

Glass, 96% Silica

Aerojet-General Corp., Structural Materials Div., Calif (r,u)
Amersil Quartz Div., Engelhard Industries, Inc., NJ (s,z,aa,bb,cc,ee)
Applied Instruments, Inc., NY (z,cc,ee)
Bassichis Co., Ohio (aa)
Bausch & Lomb Optical Co., NY (r)
Corning Glass Works, NY (r,z,aa,bb,cc,ee)—Ad p 319
Fischer & Porter Co., Pa (r)
Johns-Manville Corp., NY (s)
Kaufman Glass Co., Del (z,bb,cc,ee)
Marsco Mfg. Co., Ill (r)
Russell Mfg. Co., Conn (r,s)
Saunders, Alexander & Co., Inc., NY (aa)
Thompson, H.I. Fiber Glass Co., Calif (s)

Glass, Silica

Aerojet-General Corp., Structural Materials Div., Calif (r,u)
Applied Instruments, Inc., NY (z,cc,ee)
Bassichis Co., Ohio (aa)
Bausch & Lomb Optical Co., NY (r,
Corning Glass Works, NY (r,aa,cc)—Ad p 319
Fischer & Porter Co., Pa (r)
Friedrich & Dimmock, Inc., NJ (r)
Johns-Manville Corp., NY (s)
Kaufman Glass Co., Del (z,bb,cc,ee)
McGean Chemical Co., Ohio
Modiglass Fibers, Inc., NJ (s)
Pittsburgh Corning Corp., Pa (u)
Pyrosil, Inc., Ohio (r,z,aa,bb,cc,ee)
Semon Bache & Co., NY (z,cc,ee)
Thermal American Fused Quartz Co., NJ (r,z,bb,cc,ee)
Thompson, H.I. Fiber Glass Co., Calif (s)

Glass, Soda-Lime

Anchor Hocking Glass Co., Ohio (r)
Applied Instruments, Inc., NY (z,bb,cc,ee)
Bassichis Co., Ohio (aa)
Bausch & Lomb Optical Co., NY (r,s)
Corning Glass Works, NY (r,aa,bb,ee)—Ad p 319
Erie Scientific Corp., NY (cc)
Fischer & Porter Co., Pa (r)
Friedrich & Dimmock, Inc., NJ (r,s,bb,ee)
Kaufman Glass Co., Del (z,bb,cc,ee)
Kimble Glass Co., Sub. of Owens-Illinois Glass Co., Ohio (r,aa,bb,ee)
Kopp Glass, Inc., Pa (r)—Ad p 309
Lancaster Glass Corp., Ohio (r)
Mansol Ceramics Co., NJ (r,aa)
Modiglass Fibers, Inc., NJ (s)
Pittsburgh Plate Glass Co., Pa (z,cc)
Semon Bache & Co., NY (z,cc,ee)
Shull Bros. Glass Corp., NJ (r,bb,ee)
Thompson, H.I. Fiber Glass Co., Calif (s)

Glass Coatings

(see Inorganic Coatings)

Glass for Plastics Reinforcement

American Polyglas Corp., NJ
Bassichis Co., Ohio
Coast Mfg. & Supply Co., Calif
Electrofilm, Inc., Calif
Exeter Mfg. Co., NY
Ferro Corp., Ohio
Ferro Corp., Fiber Glass Div., Tenn —Ad p 321
Flexfirm Products, Calif
Foss Mfg. Co., Id
General Plastics Corp., NJ
Glass Textiles Div., Johns-Manville Corp., Ohio
Miller-Stephenson Chemical Co., Inc., Conn
Modiglass Fibers, Inc., NJ
Owens-Corning Fiberglas Corp., Ohio
Pittsburgh Plate Glass Co., Fiber Glass Div., Pa —Ad p 311
Pyrosil, Inc., Ohio
Ren Plastics, Inc., Mich
Rezolin, Inc., Calif
Riegel Paper Corp., NY
Russell Mfg. Co., Conn
Standard Insulation Co., Plastics Div., NJ
Stevens, J.P. & Co., Inc., NY
Tallman-McCluskey Fabrics Co., Mo
Thompson, H.I. Fiber Glass Co., Calif
Union Carbide Metals Co., Div. of Union Carbide Corp., NY

Gold and Its Alloys

Advance Stamping Co., Mich (dd)
Alpha Metals, Inc., NJ (t)
American Metal Climax, Inc., NY (w,aa)
American Platinum & Silver Div., Engelhard Industries, Inc., NY (n,o,v,z,bb,cc,dd,ee,ff)

American Platinum Works, NJ (z)
American Silver Co., NY (v,dd,ee,ff)
American Smelting & Refining Co., NY (o)
Anaconda Co., NY (o)
Anchor Metal Co., Inc., NY (w)
Baker & Co., Inc., NJ (n,o,v,w,z,bb,cc,dd)
Bart Mfg. Corp., NJ (aa)
Bishop, J. & Co. Platinum Works, Pa (v,ee,ff)
Composite Industrial Metals, Inc., RI (p)
Deringer Metallurgical Corp., Ill (cc,dd,ee,ff)
Eastern Smelting & Refining Corp., Mass (n,o,v,w,z,aa,bb,cc,dd,ee,ff)
Goldsmith Bros. Div., National Lead Co., Ill (n,o,v,w,z,aa,bb,cc,dd,ff)
Hagstoz, T.B. & Son, Pa (n,cc,dd,ff)
Handy & Harman, NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Hanovia Chemical & Mfg. Co., NJ (aa)
Hardy, Charles, Inc., NY (aa)
Hastings & Co., Inc., Pa (v)
Hayden Wire Works, Inc., Mass (ff)
Horton-Angell Co., Mass (n,o,bb,cc,dd,ee,ff)
Improved Seamless Wire Co., RI (bb,cc,dd,ee,ff)
Lakeland Industries, Minn (z)
Leach & Garner Co., Industrial Div., Mass (n,o,v,z,bb,cc,dd,ee,ff)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (n,o,v,z,bb,dd,ee,ff)
Metals Disintegrating Co., Inc., NJ (aa)
Metz Refining Co., NJ (n,o,q,z,aa,bb,cc,dd,ee,ff)
Nesor Alloy Products Co., NJ (dd,ff)
Ney, J.M. Co., Industrial Div., Conn (v,z,bb,cc,dd,ee,ff)
Norwalk Powdered Metals, Inc., Conn (aa)
Peerless Roll Leaf Co., Div. of Howe Sound Co., NJ (v,dd)
Riegel Paper Corp., NY
Sel-Rex Corp., NJ (n,aa)—Ad p 356
Standard Metals Corp., Mass (n,o,v,z,bb,cc,dd,ee,ff)
Technic, Inc., RI (aa)—Ad p 352
Texas Instruments, Inc., Metals & Controls Div., Mass (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Western Gold & Platinum Co., Sub. of Wilbur B. Driver Co., Calif (aa,cc,dd,ff)
Wildberg Bros. Smelting & Refining Co., Calif (n,o,v,w,z,aa,bb,cc,dd,ff)
Williams Gold Refining Co., Inc., NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)

Graphite

(see Carbon)

Gray Iron

(see Iron)

GR-S Rubber

(see Styrene-Butadiene Rubber)

Hard Facing Alloys

Air Reduction Sales Co., Div. of Air Reduction Co., Inc., NY
Alloy Rods Co., Pa
Alloy Surfaces Co., Inc., Del
All-State Welding Alloys Co., Inc., NY
American Brake Shoe Co., NY
American Manganese Steel Div., American Brake Shoe Co., Ill
American Smelting & Refining Co., NY
Champion Rivet Co., Ohio
Cleveland Hard Facing Co., Inc., Ohio
Crucible Steel Co. of America, Pa
Electric Steel Foundry Co., Ore
Fansteel Metallurgical Corp., Ill
General Electric Co., NY
Harnischfeger Corp., Wis
Hayden Wire Works, Inc., Mass
Haynes Stellite Co., Div. of Union Carbide Corp., Ind
Hobart Bros. Co., Ohio
Janney Cylinder Co., Pa
Kennametal, Inc., Pa
Kinkead Industries, Inc., Ill
Lincoln Electric Co., Ohio
Lincoln Iron Works, Vt
Linde Co., Div. of Union Carbide Corp., NY
Marquette Mfg. Co., Inc., Minn
McKay Co., Pa
Metal Finishers, Inc., Md
Metal & Thermit Corp., NJ
Metal-Cladding, Inc., NY
Metallizing Co. of Los Angeles Inc., Calif
Metallizing Engineering Co., Inc., NY
Moore Drydock Co., Calif
Morrisville Foundry Co., Inc., Vt
Overmyer Mould Co., Inc., Ind
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa
Republic Steel Corp., Ohio
Sommer Metalcraft Corp., Ind
Stevens, Frederic B., Inc., Mich
Stoody Co., Calif
Tiarco Corp., NJ
Uniworld Research Corp. of America, Ohio
Vanadium-Alloys Steel Co., Pa
Victor Equipment Co., Calif
Wall Colmonoy Corp., Stainless Process Div., Mich

Hard Surfaces for Metals

(see Diffusion Coatings; Hard Facing Alloys)

High Pressure Laminates

(see Laminates)

Hot Melt Coatings

(see Organic Coatings)

Hypalon

(see Chlorosulfonated Polyethylene Rubber)

Immersion Coatings, Chemical

(Incl. Electroless)

Allied Research Products, Inc., Md
Amchem Products, Inc., Pa
Automotive Rubber Co., Inc., Mich
Biddle Screw Products Co., Ind
Birchwood Chemical Co., Minn
Carboline Co., Mo
Chemical Development Corp., Mass
Dollin Corp., NJ
Electro Chemical Engineering & Mfg. Co., Pa
Engineering Products & Specialties, Inc., RI
Hughson Chemical Co., Div. of Lord Mfg. Co., Pa
Industrial Chromium Corp., Mass
Jervis Corp., Mich
Kanigen Div., General American Transportation Corp., Ill —Ad p 355
Lewco, Ohio
Lithcote Corp., Ill
MacDermid, Inc., Conn
Magnesium Co. of America, Ind
Marlane Development Co., Inc., NY
Merix Chemical Co., Ill
Metal Finishers, Inc., Md
Metal & Thermit Corp., NJ
Metal-Cladding, Inc., NY
Mitchell-Bradford Chemical Co., Conn
Modern Plating Corp., Ill
National Lock Co., Ill
Neilson Chemical Co., Mich
Nylok Corp., NJ
Octagon Process, Inc., NY
Parker Rust Proof Co., Mich
Plume & Atwood Mfg. Co., Conn
Promat Div., Poor & Co., Ill
Reynolds Chemical Products Co., Mich
Rustproofing & Metal Finishing Corp., Mass
St. Eloi Corp., Ohio
Stevens, Frederic B., Inc., Mich
Tuff Clad, Inc., Ohio
Turco Products, Inc., Calif
Union Carbide Metals Co., Div. of Union Carbide Corp., NY
WLS Stamping Co., Ohio
Wright Metalcoaters, NJ

Impact Extrusions

(cold extrusions)

Allied Products Corp., Mich (g)
Almco Steel Products Corp., Ind (b,g)
Aluminum Co. of America, Pa (a)—Ad pp 423-424
Bridgeport Brass Co., Conn (a)
Cliff Mfg. Co., Ohio (a)
Curtiss-Wright Corp., NY (g)
Cyril Bath Co., Ohio (g)
Division Lead Co., Ill (d)
Dow Chemical Co., Dow Metal Products Co. Div. Mich (e)
Fletcher Enamel Co., W.Va (a,b,c,d,e,f)
Fromson Orban Co., Inc., NY (a)
Harvey Aluminum, Calif (a)
Heintz Mfg. Co., Pa (g)
Hunter-Douglas Aluminum Div., Bridgeport Brass Co., Calif (a)
Impact Extrusions, Inc., Ind (a)
Impax, Inc., Mo (a,b,e,j)
Jervis Corp., Mich (a)
Ladish Co., Wis (a,b,c,e,f,g,h)
Leake Engineering Co., Mich (a,b,d,g)
Magline, Inc., Mich (e)
Magnesium Co. of America, Ind (a,e)
Mueller Brass Co., Mich (a,b,g)—Ad p 455
National Impacted Metal Corp., Miss (a,b,e,j)
Republic Steel Corp., Ohio (g)
Rockwell-Standard Corp., Stamping Div., NY (a,g)
Rome Mfg. Div., Revere Copper & Brass, Inc., NY (a,b)
Sherman & Reilly, Inc., Tenn (e,f,g)
Sun Tube Corp., NJ (a,b,e)
Thompson Products, Light Metals Div., Ohio (a)
Townsend Co., Engineered Fasteners Div., Pa (a,b,g)
United Shoe Machinery Corp., Mass (a)
Westinghouse Electric Corp., Materials Mfg. Corp., Pa (b,f,g)
Wirz, A.H., Inc., Pa (a,b,d,j)
Worcester Pressed Steel Co., Mass (a)

Impregnated or Compressed Wood

(see Wood)

Impregnation Coatings

(see Organic Coatings)

Indium and Its Alloys

Alpha Metals, Inc., NJ (o,q,t,w,bb,cc,dd)
American Silver Co., NY (v,dd,ee,ff)
American Smelting & Refining Co., NY (n,o,q,v,w,bb,cc,dd,ff)
Anaconda Co., NY (aa)
Belmont Smelting & Refining Works, Inc., NY (o)
Cerro de Pasco Sales Corp., NY (o,w)—Ad p 178
Division Lead Co., Ill (o,v,cc,ff)
Empire Metal Co., NY (n,o,q,w,bb,ff)
Federated Metals Div., American Smelting and Refining Co., NY (o,q,v,w,bb,cc,dd,ff)
Glidden Co., Chemical Divs., Metals Dept., Ind (aa)
Goldsmith Bros. Div., National Lead Co., Ill (o,q)
Handy & Harman, NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Hardy, Charles, Inc. NY (aa)
Indium Corp. of America, NY (n,o,q,v,w,z,aa,bb,cc,dd,ff) — Ad p 172
International Minerals and Metals Corp., NY (w)
Kelsey-Hayes Co., Utica Metals Div., NY (w)
Nesor Alloy Products Co., NJ (dd,ff)
Sel-Rex Corp., NJ (aa)—Ad p 356
Texas Instruments, Inc., Metals & Controls Div., Mass (dd)
United Refining & Smelting Co., Ill (n,o,q,w,z,bb,cc,dd,ff)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Western Gold & Platinum Co., Sub. of Wilbur B. Driver Co., Calif (dd, ff)
Williams Gold Refining Co., Inc., NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)

Ingots

(see specific metal)

Injection Moldings

(see Moldings)

Inorganic Coatings, Ceramic

(formulations)

Bisonite Co. Inc., NY
California Metal Enameling Co., Calif
Centralab Div., Globe Union, Inc., Wis
Chicago Vitreous Corp., Div. of Eagle-Picher Co., Ill
Continental Coatings Corp., Ohio
Cooley, W.J. & Co., Tenn
Dennis Chemical Co., Mo
Douglas & Sturgess, Calif
du Pont de Nemours, E.I. & Co., Inc., Del
Dyna-Therm Chemical Corp., Calif
Earl Paint Corp., NY
Electrolizing Co., Ill
France, J.H. Refractories Co., Pa
Harshaw Chemical Co., Ohio
Hayden Wire Works, Inc., Mass
Hitemp Wires, Inc., NY
Hommel, O Co., Pa
Ingram-Richardson, Inc., Ind
Kraus Research Labs, Md
Laboratory Equipment Corp., Mich
Linde Co., Div. of Union Carbide Corp., NY
Lithium Corp. of America Inc., Minn
Metal & Thermit Corp., NJ
Metallizing Engineering Co., Inc., NY
Norton Co., Mass
—Ad p 348
Refractory & Insulation Corp., NY
Sauereisen Cements Co., Pa
Solar Aircraft Co., Calif
Thermal Refractories Corp., NJ
Zirconium Corp. of America, Ohio
Zophar Mills, Inc., NY

Inorganic Coatings, Ceramic

(coaters)

American Emblem Co., Inc., NY
Bevan Co., Calif
Bisonite Co., Inc., NY
Brooks & Perkins, Inc., Mich
California Metal Enameling Co., Calif
Centralab Div., Globe Union Inc., Wis
Continental Coatings Corp., Ohio
Cooley, W.J. & Co., Tenn
Dyna-Therm Chemical Corp., Calif
Electrofilm, Inc., Calif
Electrolizing Co., Ill
Emerson & Cuming, Inc., Mass
Enamel Products Co., Ohio
Erie Ceramic Arts Co., Pa
Fletcher Enamel Co., W.Va
Galigher Co., Utah
Hayden Wire Works, Inc., Mass
Ingram-Richardson, Inc., Ind
Lancaster Glass Corp., Ohio
Linde Co., Div. of Union Carbide Corp., NY
Metal-Cladding, Inc., NY
Metallizing Co. of Los Angeles, Inc., Calif
Metaplast Process, Inc., NY
Norton Co., Mass
—Ad p 348
Russell Mfg. Co., Conn
St. Eloi Corp., Ohio
Solar Aircraft Co., Calif
Swedlow, Inc., Calif
—Ad p 263
Sylvester & Co., Ohio
Union Carbide Metals Co., Div. of Union Carbide Corp., NY
Zirconium Corp. of America, Ohio

Inorganic Coatings, Porcelain or Glass

(formulations)

American Metal Products Co., Mich
Bettinger Corp., Mass
California Metal Enameling Co., Calif
Chemical Coatings and Engineering Co., Pa
Chicago Vitreous Corp., Div. of Eagle-Picher Co., Ill
Dennis Chemical Co., Mo
Du-Co Ceramics Co., Pa
du Pont de Nemours, E.I. & Co., Inc., Del
Dyna-Therm Chemical Corp., Calif
Erie Ceramic Arts Co., Pa
Ferro Corp., Ohio
Harshaw Chemical Co., Ohio
Hitemp Wires, Inc., NY
Hommel, O. Co., Pa
Independence Stove & Mfg. Co., Mo
Ingram-Richardson, Inc., Ind
Lithium Corp. of America Inc., Minn
Metal-Cladding Inc., NY
Pemco Corp., Md
Pierce & Stevens Chemical Corp., NY
Sauereisen Cements Co., Pa
Wyandotte Chemicals Corp., Mich

Inorganic Coatings, Porcelain or Glass

(enamelers)

AllianceWall Div., AllianceWare, Inc., Ohio
American Valve & Enameling Corp., Ind
Applied Instruments, Inc., NY
Barrows Porcelain Enamel Corp., Ohio
Bettinger Corp., Mass
Bevan Co., Calif
California Metal Enameling Co., Calif
Cleveland Porcelain Enameling Co., Ohio
Emerson & Cuming, Inc., Mass
Enamel Products Co., Ohio
Erie Ceramic Arts Co., Pa
Erie Enameling Co., Pa
Ervite Co., Pa
Ferro Enameling Co., Calif
Fletcher Enamel Co., W.Va
Geuder, Paeschke & Frey Co., Wis
Heintz Mfg. Co., Pa
Independence Stove & Mfg. Co., Mo
Ingersoll Products Div., Borg-Warner Corp., Ill
Ingram-Richardson, Inc., Ind
Ingram-Richardson Mfg. Co., Pa
Kawneer Co., Mich
Lansdale Porcelain Enamel Corp., Pa
Metal & Thermit Corp., NJ
Metal-Cladding, Inc., NY
Monarch Aluminum Mfg. Co., Ohio
National Metal Products Co., Pa
Penn Fibre & Specialty Co., Inc., Pa
Philadelphia Enameling Works, Inc., Pa
Pittsburgh Plate Glass Co., Pa
Porcelain Enamel Finishers, Ill
Smith, A.O. Corp., Wis
Smoot-Holman Co., Calif
Southwestern Porcelain Steel Corp., Okla
Swedlow, Inc., Calif
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Temco, Inc., Tenn
Vollrath Co., Wis

Inorganic Fibers

(except Asbestos, Ceramic, Glass, Carbon; see these categories)

Allied Chemical Corp., Plastics & Coal Chemicals Div., NY
Baldwin-Ehret-Hill, Inc., NJ
Carborundum Co., NY
Carey, Philip Mfg. Co., Ohio
Celotex Corp., Ill
Chemore Corp., NY
Eagle-Picher Co., Ohio
Electrofilm Inc., Calif
Gustin-Bacon Mfg. Co., Mo
Johns-Manville Corp., NY
Modiglass Fibers, Inc., NJ
Standard Asbestos Mfg. Co., Ill
Thermal Refractories Corp., NJ
Union Carbide Metals Co., Div. of Union Carbide Corp., NY

Intermetallic Compounds

(see Ceramics; Refractories)

Investment Castings

(see castings)

Iron, Alloy

(castings)

Acme Foundry & Machine Co., Okla
Adirondack Steel Casting Co., NY
Advance Foundry Co., Ohio
Albion Malleable Iron Co., Mich
Alloy Precision Castings Co., Ohio
Almont Mfg. Co., Mich
Alten Foundry & Machine Works, Inc., Ohio
American Brake Shoe Co., NY
American Cast Iron Pipe Co., Ala
American Foundries Co., Mich
Apex Foundry, Inc., Mich
Apex Steel Corp., Ltd., Calif
Arzt, T.L. Foundry Co., Ill
Atlantic Foundry Co., Ohio
Banner Iron Works, Mo
Barber Iron Work, Inc., La
Bay City Foundry Co., Mich
Beaver Valley Alloy Foundry Co., Pa
Belle City Malleable Iron, Racine Steel Castings Co., Wis
Beloit Foundry Co., Ill
Bethlehem Steel Co., Pa
Bierman-Everett Foundry Co., NJ
Bignall Co., NY
Bonnot Co., Ohio
Brom Machine & Foundry Co., Minn
Butler Engine & Foundry Co., Inc., Pa
Cadillac Malleable Iron Co., Mich
Calumet Div., Calumet & Hecla, Inc., Mich
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich
Carondelet Foundry Co., Mo
Casting Service Corp. of Michigan Mich
Chambersburg Engineering Co., Pa
Chemung Foundry Corp., NY
Chicago Hardware Foundry Co., Ill
Cleveland Foundry & Mfg. Co., Inc., Tenn
Crawford & Doherty Foundry Co., Ore
Curtiss-Wright Corp., NY
Dalton Foundries, Inc., Ind
Darling Valve & Mfg. Co., Pa
Dayton Foundry, Calif
Deuscher, H.P. Co., Ohio
Durircn Co., Inc., Ohio
Ehrsam, J.B. & Sons Mfg. Co., Kan
Electric Steel Foundry Co., Ore
Electron Corp., Colo
Elk Engineering Works, Inc., Pa
Elkhart Iron Works, Mich
Engineered Castings Div., American Brake Shoe Co., NY
Enterprise Wheel & Car Corp., Va
Florence Pipe Foundry & Machine Co., NJ
Flynn & Emrich Co., Md
Forest City Foundries Co., Ohio
Frederick Iron & Steel, Inc., Md
Fremont Casting Co., Mass
G. & C. Foundry Co., Ohio
Gale Mfg. Co., Mich
General Electric Co., Foundry Dept., NY
Gillett & Eaton, Inc., Minn
Goslin Birmingham Mfg. Co., Inc., Ala
Grafton Foundry Co., Wis
Grede Foundries, Inc., Wis
Green Bay Foundry & Machine Works, Wis
Greenlee Foundry Co., Ill
Grimm Foundry Co., Inc., NJ
Gunite Foundries Corp., Ill
H & H Foundry Machine Co., Pa
Hamilton Foundry & Machine Co., Ohio
Hansell-Elcock, Ill
Helmick Foundry-Machine Co., W.Va
Hewitt, John Foundry Co., NJ
Howard Foundry Co., Ill
Irwin-Sensenich Corp., Pa
Janney Cylinder Co., Pa
Keen Foundry Co., Inc., Ind
Kingsport Foundry & Mfg. Corp., Tenn
Kolcast Industries Div., Thompson Products, Inc., Ohio
Kramer Bros Foundry Co., Ohio
Kutztown Foundry & Machine Corp., Pa
Lake Erie Foundry Co., NY
Lang-Scharmann & Co., Wis
Lawton, C.A. Co., Wis
Liberty Foundry Co., Mo
Lincoln Foundry Corp., Calif
Link-Belt Co., Ill
Littlestown Hardware & Foundry Co., Inc., Pa
Lodi Iron Works, Inc., Calif
Long Beach Iron Works, Calif
Macaulay, H.C. Foundry Co., Calif
Mackintosh-Hemphill Div., E.W. Bliss Co., Pa
Manufacturers Iron Foundry, Inc., Conn
McLanahan & Stone Corp., Pa
Meehanite Metal Corp., NY
—Ad p 461
Mercast Mfg. Corp., Calif
Metropolitan Iron Foundry, NY
Midwestern Foundries, Inc., Ind
Montague Machine Co., Mass
National Malleable & Steel Castings Co., Ohio
Neenah Foundry Co., Wis
North Wales Foundry Co., Inc., Pa
Oak Hill Foundry & Machine Works, Ohio
Oakland Foundry & Machine Co., Mich
Oil City Iron Works, Tex
Overmyer Mould Co., Inc., Ind
Parker-Street Castings Co., Ohio
Perkins, Henry Co., Mass
Pittsburgh Foundry & Machine Co., Pa
Pohlman Foundry Co., Inc., NY
Posey Iron Works, Inc., Pa
Potts, C. & G. & Co., Ind
Prescott Co., Mich
Pusey & Jones Corp., Del
Quaker Alloy Casting Co., Pa
Republic Steel Corp., Ohio
Richmond Foundry & Mfg. Co., Inc., Va
Ridge Foundry, Calif
Riverside Foundry & Galvanizing Co., Mich
Rosedale Foundry & Machine Co., Pa
Ross-Meehan Foundries, Tenn
Ryerson, Joseph T. & Son, Inc., Ill
St. Marys Foundry Co., Ohio
Schaefer-Goodnow Foundries, Inc., Pa
Schneider, Bowman Co., Inc., Pa
Scudder, E.J. Foundry & Machine Co., NJ
Shakopee Foundry Co., Minn
Shartle Div., Black-Clawson Co., Ohio
Sheffield Foundry Co., Ill
Shenango Furnace Co., Centrifugally Cast Products Div., Ohio
Sibley Machine & Foundry Corp., Ind
Sioux City Foundry & Boiler Co., Iowa
Sonith Foundries Div., Food Machinery & Chemical Corp., Ind
Sorbo-Mat Process Engineers, Mo

Sparta Foundry Div., Muskegon Piston Ring Co., Mich
Springfield Foundry Co., Mass
Spuck Iron & Foundry Co., Mo
Star Heel Plate Co., Inc., NJ
Stuart Foundry Co., Mich
Superior Foundry, Inc., Ohio
Taylor & Co., Inc., NY
Taylor & Boggis Foundry, Ohio
Taylor-Wharton Co., Div. of Harsco Corp., NJ
Texas Foundries, Inc., Tex
Tower Grove Foundry, Mo
Union Iron Works, Wash
United Shoe Machinery Corp., Mass
U.S. Pipe & Foundry Co., Ala
Uniworld Research Corp. of America, Ohio
Valley Iron Works, Minn
Wall Colmonoy Corp., Stainless Process Div., Mich
Washington Iron Works, Wash
Waterman Industries, Inc., Calif
West Point Foundry & Machine Co., Div. of Batson-Cook Co., Ga
Zenith Foundry Co., Wis

Iron, Gray

(castings)

ACF Industries, Inc., NY
Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa
Acme Foundry & Machine Co., Kan
Acme Foundry & Machine Co., Okla
Advance Foundry Co., Ohio
Albert Lea Foundry-Queen Products Div., King-Seeley Corp., Minn
Allegheny Foundry Co., Pa
Allis-Chalmers Mfg. Co., Wis
Alloy Precision Castings Co., Ohio
Almont Mfg. Co., Mich
Alten Foundry & Machine Works, Inc., Ohio
American Brake Shoe Co., NY
American Cast Iron Pipe Co., Ala
American Foundries Co., Mich
American Foundry Co., Inc., Ind
American Laundry Machinery Co., NY
Apex Foundry, Inc., Mich
Apex Steel Corp., Ltd., Calif
Appleton Electric Co., Ill
Arneson Foundry Co., Wis
Arzt, T.L. Foundry Co., Ill
Atlantic Foundry Co., Ohio
Atlas Foundry Co., Ohio
Atlas Foundry & Mfg. Co., Calif
Auburn Foundry, Inc., Ind
Avco Mfg. Corp., New Idea Div., NY
Banner Iron Works, Mo
Barber Iron Works Inc., La
Barnett Foundry & Machine Co., NJ
Bay City Foundry Co., Mich
Becker, L.A. Foundry Co., Mo
Bellaire Stove Co., Ohio
Belle City Malleable Iron, Racine Steel Castings Co., Wis
Beloit Foundry Co., Ill
Bethlehem Steel Co., Pa
Bierman-Everett Foundry Co., NJ
Bignall Co., NY
Black-Clawson Co., Ohio
Bond, Charles Co., Pa
Bonnot Co., Ohio
Brake Shoe & Castings Div., American Brake Shoe Co., NY
Bruce Foundry and Mfg. Co., Mich
Butler Engine & Foundry Co., Inc., Pa
Calumet Div., Calumet & Hecla, Inc., Mich
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich
Carondelet Foundry Co., Mo
Casting Service Corp. of Michigan, Mich
Central Specialty Div., King-Seeley Corp., Mich
Chambersburg Engineering Co., Pa.
Chemung Foundry Corp., NY
Chicago Hardware Foundry Co., Ill
Cincinnati Foundry Co., Ohio
Cleveland Foundry & Mfg. Co., Inc., Tenn
Columbiana Pump Co., Ohio
Compton Foundry, Calif
Continental Gin Co., Ala
Cooper-Bessemer Corp., Ohio
Crawford & Doherty Foundry Co., Ore
Dalton Foundries, Inc., Ind
Dana Corp., Auburn Div., Ind
Darling Valve & Mfg. Co., Pa
Dayton Malleable Iron Co., Ohio
Decatur Casting Co., Ind
De Laval Steam Turbine Co., NJ
Detroit Brass & Malleable Co., Mich
Deuscher, H.P. Co., Ohio
Dexter Foundry Div., Philco Corp., Iowa
Dodge Mfg. Co., Ind
Dostal Foundry & Machine Co., Mich
Eaton Mfg. Co., Foundry Div., Mich
Ehrsam, J.B. & Sons Mfg. Co., Kan
Electron Corp., Colo
Elk Engineering Works, Inc., Pa
Elkhart Foundry & Machine Co., Inc., Ind
Elkhart Iron Works, Mich
Empire Pattern and Foundry Co., Okla
Engineered Castings Div., American Brake Shoe Co., NY
Enterprise Wheel & Car Corp., Va
Fearon Foundry Co., Ill
Florence Pipe Foundry & Machine Co., NJ
Florin Foundry & Mfg. Co., Pa
Flynn & Emrich Co., Md
Forest City Foundries Co., Ohio
Frederick Iron & Steel, Inc., Md
Fremont Casting Co., Mass
Fulton Foundry & Machine Co., Inc., Ohio
G. & C. Foundry Co., Ohio
Gale Mfg. Co., Mich
Gartland-Haswell Foundry, Inc., Ohio
General Electric Co., Foundry Dept., NY
General Foundry & Mfg. Co., Mich
General Iron Works Co., Colo
General Motors Corp., Central Foundry Div., Mich
Georgia Iron Works, Ga
Gillett & Eaton, Inc., Minn
Glamorgan Pipe & Foundry Co., Va
Goslin-Birmingham Mfg. Co., Inc., Ala
Gowanda Furnaces, Inc., NY
Grafton Foundry Co., Wis
Grede Foundries, Inc., Wis
Green Bay Foundry & Machine Works, Wis
Greenlee Foundry Co., Ill
Grimm Foundry Co., Inc., NJ
Gunite Foundries Corp., Ill
H & H Foundry Machine Co., Pa
Hamilton Foundry & Machine Co., Ohio
Hansell-Elcock, Ill
Hardinge Mfg. Co., Pa
Headford Bros. & Hitchins Foundry Co., Iowa
Helmick Foundry-Machine Co., W.Va
Hewitt, John Foundry Co., NJ
Hodgson Foundry Co., Ill
Howard Foundry Co., Ill
Independence Stove & Mfg. Co., Mo
Industrial & Furnace Car Div., Irwin-Sensenich Corp., Pa
International Harvester Co., Ill
Janney Cylinder Co., Pa
Johnstone Foundries, Inc., Pa
Kanawha Mfg. Co., W.Va
Kansas City Hay Press Co., Mo
Kateiman Foundry & Mfg. Co., Iowa
Keen Foundry Co., Inc., Ind
Kelly Foundry Co., Pa
Kingsport Foundry & Mfg. Corp., Tenn
Koehring Co., Wis
Kramer Bros. Foundry Co., Ohio
Kutztown Foundry & Machine Corp., Pa
Lake Erie Foundry Co., NY
Lakeside Malleable Casting Co., Wis
Lang-Scharmann & Co., Wis
Lawton, C.A. Co., Wis
Le Baron, E.L. Foundry, Mass
Lehigh, Inc., Pa
Letukas Foundry Inc., Ind
Lewistown Foundry & Machine Co., Pa
Liberty Foundry Co., Mo
Lincoln Foundry Corp., Calif
Lincoln Iron Works, Vt
Link-Belt Co., Ind
Littite Foundries, Inc., Mich
Littlestown Hardware & Foundry Co., Inc., Pa
Lodge Mfg. Co., Tenn
Lodi Iron Works, Inc., Calif
Long Beach Iron Works, Calif
Macaulay, H.C. Foundry Co., Calif
Madison Foundry Co., Ohio
Magirl Foundry & Furnace Co., Ill
Manufacturers Iron Foundry, Inc., Conn
McCarter Iron Works, Inc., Pa
McLanahan & Stone Corp., Pa
Meehanite Metal Corp., NY
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Mercast Mfg. Corp., Calif
Metropolitan Iron Foundry, NY
Midwestern Foundries, Inc., Ind
Milwaukee Malleable & Grey Iron Works, Wis
Montague Machine Co., Mass
Morrisville Foundry Co., Inc., Vt
National Grey Iron Foundry, Ill
National Malleable & Steel Castings Co., Ohio
National Supply Co., Pa
Neenah Foundry Co., Wis
Noble & Wood Machine Co., NY
North Wales Foundry Co., Inc., Pa
Oak Hill Foundry & Machine Works, Ohio
Oakland Foundry & Machine Co., Mich
Oil City Iron Works, Tex
Overmyer Mould Co., Inc., Ind
Palmyra Foundry Co., Inc., NJ
Parker-Street Castings Co., Ohio
Pequonnock Foundry, Inc., Conn
Perkins, Henry Co., Mass
Pittsburgh Foundry & Machine Co., Pa
Pohlman Foundry Co., Inc., NY
Posey Iron Works, Inc., Pa
Potts, C. & G. & Co., Ind
Prescott Co., Mich
Pusey & Jones Corp., Del
Refinery Castings Co., Tex
Republic Steel Corp., Ohio
Richmond Foundry & Mfg. Co., Inc., Va
Ridge Foundry, Calif
Riverside Foundry Co., Pa
Riverside Foundry & Galvanizing Co., Mich
Rockwell Engineering Co., Ill
Rodney Hunt Machine Co., Mass
Rosedale Foundry & Machine Co., Pa
Ross-Meehan Foundries, Tenn
Ryerson, Joseph T. & Son, Inc., Ill
St. Marys Foundry Co., Ohio
San Francisco Iron Foundry, Calif
Savannah Machine & Foundry Co., Foundry Div., Ga
Schaefer-Goodnow Foundries, Inc., Pa
Schneider, Bowman Co., Inc., Pa
Scudder, E.J. Foundry & Machine Co., NJ
Selma Foundry & Machine Co., Ala
Shakopee Foundry Co., Minn
Shartle Div., Black-Clawson Co., Ohio
Sheffield Foundry Co., Ill
Shenango Furnace Co., Centrifugally Cast Products Div., Ohio
Sibley Machine & Foundry Corp., Ind
Sioux City Foundry & Boiler Co., Iowa
Somerset Foundry & Machine Co., Pa
Sonith Foundries Div., Food Machinery & Chemical Corp., Ind
Sorb-Mat Process Engineers, Mo
Southern Car & Mfg. Co., Inc., Ala
Sparta Foundry Div., Muskegon Piston Ring Co., Mich
Spencer's, I.S. Sons, Inc., Conn
Spring City Foundry Co., Pa
Springer's Foundry Co., Inc., Ind
Springfield Foundry Co., Mass
Spuck Iron & Foundry Co., Mo
Star Heel Plate Co., Inc., NJ
Stearns-Roger Mfg. Co., Colo
Sterling Foundry Co., Ill
Sterrit-Thomas Foundry Co., Pa
Stuart Foundry Co., Mich
Superior Foundry, Inc., Ohio
Swayne-Robinson & Co., Ind
Swett, A.L. Iron Works, NY
Taylor & Co., Inc., NY
Taylor & Boggis Foundry, Ohio
Terre Haute Malleable & Mfg. Corp., Ind
Texas Foundries, Inc., Tex
Tower Grove Foundry, Mo
Union Iron Works, Wash
United Shoe Machinery Corp., Mass
U.S. Pipe & Foundry Co., Ala
Utica General Jobbing Foundry, Inc., NY
Valley Iron Works, Minn
Vulcan Foundry Co., Calif
Vulcan Rail & Construction Co., NY
Washington Iron Works, Wash
Waterman Industries, Inc., Calif
Werner Foundry & Machine Co., Pa
West Point Foundry & Machine Co., Div. of Batson-Cook Co., Ga
Western Foundry & Machine Works, Inc., Kan
Western Iron & Foundry Co., Inc., Kan
Westinghouse Electric Corp., Materials Mfg. Dept., Pa
Wheland Co., Tenn
Wollaston Foundry Corp., Mass

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Woodruff & Edwards, Inc., Ill
Yale & Towne Mfg. Co., Ill
Zellner Foundry Co., Ohio
Zenith Foundry Co., Wis

Iron, Ingot

Alten Foundry & Machine Works, Inc., Ohio (o)
Armco Steel Corp., Ohio (o,q,z,bb,cc, dd)
Cannon-Muskegon Corp., Mich (w)
Crucible Steel Co. of America, Pa (w)
Crucible Steel Co. of America, Titanium & Vacuum Metal Products Div., Pa (o,q,z,bb,cc,dd,ff)
Foote Mineral Co., Pa (aa)
Hayden Wire Works, Inc., Mass (o, bb,ee,ff)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
National Moldite Co., NY (aa)
National-U.S. Radiator Corp., Plastic Metals Div., NY (aa)
Nesor Alloy Products Co., NJ (ff)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb,ee)
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa (ff)
Rathbone Corp., Mass (o,bb)
Republic Steel Corp., Ohio (w,aa)
Shenango Furnace Co., Centrifugally Cast Products Div., Ohio (o,ee)
Star Heel Plate Co., Inc., NJ (bb)
Superior Tube Co., Pa (ee)
Sylvania Electric Products, Inc., Parts Div., Pa (ff)
Tube Methods Inc., Pa (ee)

Iron, Malleable

(castings)

Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa
Acme Steel & Malleable Iron Works, NY
Albion Malleable Iron Co., Mich
Alloy Precision Castings Co., Ohio
American Chain & Cable Co., Pa
American Malleable Castings Co., Ohio
American Steel and Wire Div., U.S. Steel Corp., Ohio
Appleton Electric Co., Ill
Auto Specialties Mfg. Co., Mich
Badger Malleable & Mfg. Co., Wis
Belle City Malleable Iron, Racine Steel Castings Co., Wis
Cadillac Mallable Iron Co., Mich
Chicago Malleable Castings Co., Ill
Connecticut Malleable Castings Co., Conn
Dana Corp., Auburn Div., Ind
Dayton Malleable Iron Co., Ohio
Detroit Brass & Malleable Co., Mich
Eastern Malleable Iron Co., Del
General Electric Co., Foundry Dept., NY
General Motors Corp., Central Foundry Div., Mich
Hodgson Foundry Co., Ill
Iowa Malleable Iron Co., Iowa
Jamestown Malleable Iron Corp., NY
Laconia Malleable Iron Co., NH
Lake City Malleable Co., Ohio
Lakeside Malleable Castings Co., Wis
Lancaster Malleable Castings Co., Pa
Lehigh, Inc., Pa
Lincoln Foundry Corp., Calif
Link-Belt Co., Ind
McCarter Iron Works, Inc., Pa
Meadville Malleable Iron Co., Pa
Meeker Foundry Co., NJ
Metropolitan Iron Foundry, NY
Milwaukee Malleable & Grey Iron Works, Wis
Molina Iron Works, Ill
Muncie Malleable Foundry Co., Ind
National Malleable & Steel Castings Co., Ohio
Northern Malleable Iron Co., Minn
Pennsylvania Malleable Iron Corp., Pa
Prescott Co., Mich
Rockwell Engineering Co., Ill
St. Louis Malleable Castings Co., Mo
Sorbo-Mat Process Engineers, Mo
Star Heel Plate Co., Inc., NJ
Superior Steel & Malleable Castings Co., Mich
Terre Haute Malleable & Mfg. Corp., Ind
Texas Foundries Inc., Tex
United Shoe Machinery Corp., Mass
U.S. Challenge & Challenge Co., Ill
Vulcan Rail & Construction Co., NY
West Virginia Malleable Iron Co., W.Va
Westmoreland Malleable Iron Co., NY

Iron, Malleable Pearlitic

(castings)

Albion Malleable Iron Co., Mich
Auto Specialties Mfg. Co., Mich
Badger Malleable & Mfg. Co., Wis
Belle City Malleable Iron Co., Wis
Cadillac Mallable Iron Co., Mich
Canton Malleable Iron Co., Ohio
Chain Belt Co., Wis
Crane Co., Metals Div., Pa
Dalton Foundries, Inc., Ind
Dayton Malleable Iron Co., G.H.R. Div., Ohio
Eastern Malleable Iron Co., Del
Erie Malleable Iron Co., Pa
Federal Malleable Co., Wis
General Motors Corp., Central Foundry Div., Mich
I-F Mfg. Co., Ohio
Jamestown Malleable Iron Corp., NY
Laconia Malleable Iron Co., NH
Lakeside Malleable Casting Co., Wis
Lehigh Foundries Co., Div. of Lehigh Inc., Pa
Link-Belt Co., Ill
Meadville Malleable Iron Co., Pa
Milwaukee Malleable & Grey Iron Works, Wis
Moline Malleable Iron Co., Ill
National Malleable & Steel Castings Co., Ohio
Northern Malleable Iron Co., Minn
Peoria Malleable Casting Co., Ill
Pratt, William E. Mfg. Co., Ill
St. Louis Malleable Casting Co., Mo
Texas Foundries, Inc., Tex
Wagner Malleable Iron Co., Ill
Webster Mfg., Inc., Ohio

Iron, Nodular or Ductile

(castings)

Acme Foundry & Machine Co., Okla
Adirondack Steel Casting Co., NY
Advance Foundry Co., Ohio
Alloy Precision Castings Co., Ohio
Alten Foundry & Machine Works Inc., Ohio
American Brake Shoe Co., NY
American Cast Iron Pipe Co., Ala
Apex Foundry, Inc., Mich
Artz, T. L. Foundry Co., Ill
Atlantic Foundry Co., Ohio
Bay City Foundry Co., Mich
Beloit Foundry Co., Ill
Bethlehem Steel Co., Pa
Black-Clawson Co., Ohio
Bonnot Co., Ohio
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich
Chambersburg Engineering Co., Pa
Chicago Hardware Foundry Co., Ill
Crawford & Doherty Foundry Co., Ore
Curtiss-Wright Corp., Metals Processing Div., NY
Dayton Foundry, Calif
Deuscher, H.P. Co., Ohio
Dodge Steel Co., Pa
Ductile Iron Foundry, Inc., Conn
Electron Corp., Colo
Engineered Castings Div., American Brake Shoe Co., NY
Goslin Birmingham Mfg. Co., Inc., Ala
Grede Foundries, Inc., Wis
Gunite Foundries Corp., Ill
Hamilton Foundry & Machine Co., Ohio
Hansell-Elcock, Ill
Hodgson Foundry Co., Ill
Howard Foundry Co., Ill
Jamestown Malleable Iron Corp., NY
Janney Cylinder Co., Pa
Kutztown Foundry & Machine Corp., Pa
Lincoln Foundry Corp., Calif
Macauley, H.C. Foundry Co., Calif
Meehanite Metal Corp., NY
—Ad p 461
Mercast Mfg. Corp., Calif
Montague Machine Co., Mass
Neenah Foundry Co., Wis
Oil City Iron Works, Tex
Pohlman Foundry Co., Inc., NY
Pratt, William E. Foundry Div., Joslyn Mfg. & Supply Co., Ill
Rosedale Foundry & Machine Co., Pa
Ross-Meehan Foundries, Tenn
Sandy Hill Iron & Brass Works, NY
Savannah Machine & Foundry Co., Foundry Div., Ga
Shenango Furnace Co., Centrifugally Cast Products Div., Ohio
Sioux City Foundry & Boiler Co., Iowa
Southern Car & Mfg. Co., Inc., Ala
Stuart Foundry Co., Mich
Taylor-Wharton Co., Div. of Harsco Corp., NJ
Texas Foundries, Inc., Tex
United Shoe Machinery Corp., Mass

Iron, Powders

Alan Wood Steel Co., Pa
Alloy Metal Powders, Inc., Iowa
Antara Chemicals, Div. of General Aniline & Film Corp., NY
Belmont Smelting & Refining Works, Inc., NY
Crane Co., Metals Div., Pa
Easton Metal Powder Co., Div. of American Mannex Corp., Pa
Ekstrand & Tholand, NY
Foote Mineral Co., Pa
Globe Steel Abrasive Co., Ohio
Hardy, Charles, Inc., NY
Hoeganaes Sponge Iron Corp., NJ
—Ad p 462
Johnson, A. & Co., Inc., NY
Magnetic Powders, Inc., Pa
National Moldite Co., NJ
National-U.S. Radiator Corp., Plastic Metals Div., NY
Norwalk Powdered Metals, Inc., Conn
Pyron Corp., NY
—Ad p 432
Republic Steel Corp., Ohio
Shakopee Foundry Co., Minn
Sorbo-Mat Process Engineers, Mo
Steel Shot Producers, Inc., Pa
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
Uniworld Research Corp. of America, Ohio

Iron, Wrought

Albert Pipe Supply Co., Inc., NY (ee)
American Silver Co., NY (v,dd)
Byers, A.M., Pa (o,q,z,ee)
Dormont Mfg. Co., Pa (ee)
Gary Steel Products Corp., Va (o,z,bb)
Lockhart Iron & Steel Co., Pa (o, q,bb,dd)
National Electric Div., H.K. Porter Co., Pa (ee)
Rathbone Corp., Mass (o,bb)
Ryerson, Joseph T. & Son, Inc., Ill (ee)
Shaw-Kendall Engineering Co., Ohio (ee)
Titanium & Vacuum Metal Products Div., Crucible Steel Co. of America, Pa (o,q,z,bb,cc,dd,ff)
Vulcan Rail & Construction Co., NY (o,dd,ee)

Isocyanates

(see Urethanes)

Isoprene - Isobutylene Rubber

Adhesive Products Corp., NY (x)
Armstrong Cork Co., Pa (bb,cc,dd)
Atlas Mineral Products Co., Pa (cc)
Automotive Rubber Co., Inc., Mich (cc,dd)
Belko Corp., Md (y)
Bond International, Inc., Mich (y,ee)
Brown Rubber Co., Inc., Ind (u)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chicago-Allis Mfg. Corp., Ill (p)
Continental Rubber Works, Pa (bb,cc, dd,ee)
Dayton Rubber Co., Ohio (y,bb,cc,dd, ee)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
Electro Chemical Engineering & Mfg. Co., Pa (t,cc)
Enjay Chemical Co. Div., Humble Oil & Refining Co., NY
(p)—Ad pp 266-267
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass (y,cc,ee)
Garlock Packing Co., NY (y,cc)
Geauga Industries Co., Ohio (y,bb,dd)
Goshen Rubber Co., Inc., Ind
(y)—Ad p 438
Hewitt-Robins, Inc., Conn (cc,ee)
Maloney, F.H. Co., Tex (y)
Martin Rubber Co., Inc., NJ (y,dd,ee)
Mid-States Rubber Products, Inc., Ind (y)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (x)
Paeco Rubber Co., Inc., Ohio (y,dd,ee)
Parker Seal Co., Div. of Parker-Hannifin Corp., Calif (u)
Parker, Stearns & Co., Inc., NY (y, bb,cc,dd,ee)
Pawling Rubber Corp., NY (bb,dd,ee)
Polymer Chemical Co., Ohio (x)
Rand Rubber Co., NY (t,cc)
Raybestos-Manhattan, Inc., Plastic Products Div., Pa (x)
Republic Rubber Div., Lee Rubber & Tire Corp., Ohio (p,y,ee)
Roberts Toledo Rubber Co., Ohio (ee)
Rogers Corp., Conn (cc,dd)
Roth Rubber Co., Ill (y,cc)
Sheller Mfg. Corp., Mich (u)
Standard Products Co., Mich (y)
Stockwell Rubber Co., Inc., Pa (y, cc,dd)
Technical Specialties Co., NY (dd)
Trostel, Albert Packing, Ltd., Wis (y)
U.S. Rubber Co., Kem-Blo Dept., Conn
(u)—Ad p 250
Vulcan Rubber Products Div., Reeves Bros. Inc., NY (p,y,cc)
Vulcanized Rubber & Plastics Co., Pa (y)
Western Felt Works, Ill (y,cc,dd,ee)
Williams-Bowman Rubber Co., Ill (y,bb,cc,dd,ee)

Lacquers

(see Organic Coatings)

Laminates

(see below; also Pre-Impregnated Materials)

Laminates, High Pressure, Plastics or Rubber

(sheet, rod or tube; incl. clad laminates)

Acme Specialties, Inc., Pa (k,l,m)
Aerojet-General Corp., Structural Materials Div., Calif (l)
Allied Resinous Products, Inc., Ohio (k)

American Agile Corp., Ohio (k)
American Brakeblok Div., American Brake Shoe Co., Mich (k)
American Hard Rubber Co., Div. of Amerace Corp., NJ (k,l)
American Polyglas Corp., NJ (l)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Artmor Plastics Corp., Md (l)
Auburn Plastic Engineering, Ill (k)
Baer, N.S. Co., NJ (l)
Bolta Products Div., General Tire & Rubber Co., Mass (k)
Brinkerhoff Brass & Bronze Works, Inc., NY (l)
Cadillac Plastic & Chemical Co., Mich (l)
Calfibe Co., Inc., Calif (l)
Castle Rubber Co., Pa (m)
Coating Products, Inc., NJ (l)
Colonial Art Co., Inc., Mass (k)
Conneaut Rubber and Plastics Co., Div. of U.S. Stoneware Co., Ohio (k,l,m)
Connecticut Hard Rubber Co., Conn (m)
Conolite Div., Continental Can Co., Del (l)
Consoweld Corp., Wis (l)
Continental Rubber Works, Pa (m)
Continental-Diamond Fibre Corp., Del (k,l)
Curbell, Inc., NY (l)
Davidson Rubber Co., Mass (m)
Davis, Joseph Plastics Co., NJ (k)
Delta Plastics Co., NJ (l)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (m)
Dumont Corp., Ill (k,l,m)
Everlite Corp., Wash (l)
Fabricon Products Div., Eagle-Picher Co., Mich (l)
Farley & Loetscher Mfg. Co., Plastics Div., Iowa
(l)—Ad p 276
Formica Corp., Sub. of American Cyanamid Co., Ohio (l)
Gatke Corp., Ill (l)
General Electric Co., Laminated Products Dept., Ohio (l)
General Plastics Corp., NJ (k,l)
General Tire & Rubber Co., Ind (l)
H & R Industries, Pa (k)
Halogen Insulator & Seal Corp., Ill (l)
Hartwell, H.N. & Son, Inc., Mass (k)
Haskelite Mfg. Corp., Mich (l)
Haveg Industries, Inc., Del (l)
Home Rubber Co., NJ (m)
Insulation Mfrs. Corp., Ill (k)
Iten Fibre Co., Ohio (l)
Johns-Manville Corp., NY (k,l)
Kaykor Industries, Inc., Div. of Kaye-Tex Mfg. Corp., NJ (k)
Kerrco, Neb (k,l)
Lewis, J.P. Co., Plastic Products Div., NY (l)
Luminous Resins, Inc., Ill (k)
Maloney, F.H. Co., Tex (l)
Marblette Corp., NY (l)
Mechanical Rubber Products Co., NY (l)
Mica Corp., Calif (l)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (l)
Micarta Div., Westinghouse Electric Corp., SC (l)
Moxness Products, Inc., Wis (l,m)
National Vulcanized Fibre Co., Del
(l)—Ad p 249
New England Laminates Co., Inc., Conn
(l)—Ad p 281
Northern Plastics Corp., Wis (l)
Panelyte Div., St. Regis Paper Co., NJ (l)
Penn Fibre & Specialty Co., Inc., Pa (l)
Permali, Inc., Pa
(l)—Ad p 431
Philrus Products Co., NJ (k,l)
Porter, William Co., Calif (l)
Reinhold Engineering & Plastics Co., Inc., Calif (l)
Ren Plastics, Inc., Mich (l)
Replac Corp., Ohio (k,l,m)
Richardson Co., NY (l)
Reflin Co., Calif (l)
Rogers Corp., Conn (l)
Ryerson, Joseph T. & Son, Inc., Ill (l)
Seiberling Rubber Co., Plastics Div., Ohio (k,m)
Shamban, W.S. & Co., Ind (k)
Sillcocks Miller Co., NJ (k)
Spaulding Fibre Co., Inc., NY
(l)—Ad p 255
Standard Insulation Co., NJ (l)
Sun Steel Co., Ill (k)
Swedlow, Inc., Calif
(k,l)—Ad p 263
Synthane Corp., Pa
(l)—Ad p 234
Taylor Fibre Co., Pa
(l)—Ad p 246
Thermoid Div., H.K. Porter Co., Pa (k,m)
Thombert, Inc., Iowa (l)
U. S. Gasket Plastics Div., Garlock Packing Co., NJ (k)
Vulcan Rubber Products Div., Reeves Bros. Inc., NY (m)
Vulcanized Rubber & Plastics Co., Pa (m)
Westlake Plastics Co., Pa (l)

Laminates, Low Pressure, Plastics or Rubber

(sheet, rod or tube; incl. clad laminates)

Acme Specialties, Inc., Pa (k,l,m)
Aerojet-General Corp., Structural Materials Div., Calif (l)
Allegheny Plastics, Inc., Pa (k)
Allied Resinous Products, Inc., Ohio (k)
Alsynite Co. of America, Calif (l)
American Agile Corp., Ohio (k)
American Brake Shoe Co., NY (k)
American Insulator Corp., Pa (l)
American Polyglas Corp., NJ (l)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (m)
Artmor Plastics Corp., Md (l)
Atlas Powder Co., Chemicals Div., Del
(k)—Ad p 262
Auburn Plastic Engineering, Ill (l)
Baer, N.S. Co., NJ (l)
Biggs, Carl H. Co., Inc., Calif (l)
Blank, Arthur & Co., Inc., Mass (k)
Brinkerhoff Brass & Bronze Works, Inc., NY (l)
Cadillac Plastic & Chemical Co., Mich (k,l)
Calfibe Co., Inc., Calif (l)
Carroll, J.B. Co., Ill (k)
Castle Rubber Co., Pa (m)
Clad-Rex Corp., Ill (k)
Coating Products, Inc., NJ (l)
Connecticut Hard Rubber Co., Conn (m)
Consolidated Molded Products Corp., Pa (l)
Continental Can Co., NY (l)
Continental Rubber Works, Pa (m)
Continental-Diamond Fibre Corp., Del (k,l)
Corite Products Inc., Ill (l)
Corrulux Div., L.O.F. Glass Fibers Co., Tex (l)
Delta Plastics Co., NJ (l)
Dumont Corp., Calif
(k,l,m)—Ad p 428
Dura Plastics of New York, Inc., NY (k)
Eljay Corp., Md (k,l)
Emerson & Cuming, Inc., Mass (k,l,m)
Everlite Corp., Wash (l)
Fiber Glass Industries, Inc., NY (l)
Fiberglass Ohio Inc., Ohio (l)
Filon Plastics Corp., Calif (l)
Foss Mfg. Co., Id (l)
Frost Rubber Co., Ill (m)
Fry Plastics International, Calif (k)
General Plastics Corp., Ind (k)
General Plastics Corp., NJ (k,l)
Gering Plastics, Div. of Studebaker-Packard Corp., NJ (k)
Glastic Corp., Ohio
(l)—Ad p 256
Haskelite Mfg. Corp., Mich (l)
Haveg Industries, Inc., Del (l)
Hays Mfg. Co., Pa (l)
Hell Process Equipment Corp., Ohio (l)
Home Rubber Co., NJ (m)
Insulation Mfrs. Corp., Ill (k)
Kaykor Industries, Inc., NJ (k)
Kerrco, Neb (k,l)
Kevinite Div., Swedlow, Inc., Ohio (l)
Koch, H. & Sons, Calif (l)
Laminated Plas-Tex Corp., Ohio (k)
Lamtex Industries, Inc., NY (l)
Lewis, G.B. Co., Wis
(l)—Ad p 432
Lun Laminates, Inc., NY (l)
Mechanical Rubber Products Co., NY (l)
Mica Corp., Calif (l)
Mica Insulator Co., NY (l)
Micarta Div., Westinghouse Electric Corp., SC (l)
Minnesota Mining & Mfg. Co., Reinforced Plastics Div., Minn
(l)—Ad pp 258-259
National Vulcanized Fibre Co., Del (l)
New England Laminates Co., Inc., Conn (l)
Penn Fibre & Specialty Co., Inc., Pa (l)
Permali, Inc., Pa (l)
Perry Plastics Inc., Pa (k,l)
Philrus Products Co., NJ (k,l)
Polygon Plastic Co., Ind (l)
Porter, William Co., Calif (l)
Precision Paper Tube Co., Ill (l)
Rand Rubber Co., NY (k,l)
Reinhold Engineering & Plastics Co., Inc., Calif (l)
Reflin Co., Calif (l)
Ren Plastic, Inc., Mich (l)
Replac Corp., Ohio (l,m)
Resolite Corp., Pa (l)
Riverside Plastics Corp., NY (l)
Rowland Products, Inc., Conn (k)
Rubatex Div., Great American Industries, Inc., Va (u)
Rubber Corp. of America, NY (k)
Russell Reinforced Plastics Corp., NY (l)
Schorl Process Div., Ferro-Co Corp., NY (l)
Scranton Plastic Laminating Corp., Pa (k)
Sealview Plastics, Inc., Pa (l)
Sewell Mfg. Co., Mich (k)
Shamban, W.S. & Co., Ind (k)
Sierra Electric Corp., Calif (l)
Sillcocks Miller Co., NJ (k)
Southern Plastics Co., SC (k)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (k)
Standard Insulation Co., NJ (l)
Stockwell Rubber Co., Inc., Pa (k,m)
Strick Plastics Co., Pa (m,k,l)
Swedlow, Inc., Calif. (k,l)
U.S. Rubber Co., NY (k)
Urrite Plastics Fabricators, Calif (k)
Vulcan Rubber Products Div., Reeves Bros. Inc., NY (m)
Vulcanized Rubber & Plastics Co., Pa (m)
Westlake Plastics Co., Pa (l)
Winner Mfg. Co., Inc., NJ (l)
Woodall Industries, Inc., Mich (k,l)
Youngstown Sheet & Tube Co., Ohio (l)
Zenith Plastics Co., Sub. of Minnesota Mining & Mfg. Co., Calif (l)

Laminates, High or Low Pressure, Plastics or Rubber—Moldings

(incl. clad laminates)

Admiral Corp., Molded Products Div., Ill (l)
Aerojet-General Corp., Structural Materials Div., Calif (l)
Allied Resinous Products, Inc., Ohio (k)
American Agile Corp., Ohio (k)
American Brakeblok Div., American Brake Shoe Co., Mich (k)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Arrowhead Products, Calif (l,m)
Artmor Plastics Corp., Md (l)
Baer, N.S. Co., NJ (l)
Brunswick Corp., Defense Products Div., Mich (l)
Byers, A.M. Co., Pa (k)
Cadillac Plastic & Chemical Co., Mich (k,l)
Calfibe Co., Inc., Calif (l)
Camfield Fiberglass Plastics, Inc., Mich (l)
Carroll, J.B. Co., Ill (k)
Castle Rubber Co., Pa (m)
Colonial Art Co., Inc., Mass (k)
Colonial Rubber Co., Div. of U.S. Stoneware Co., Ohio (k,m)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Continental Rubber Works, Pa (m)
Continental-Diamond Fibre Corp., Del (k,l)
Corite Products, Inc., Ill (l)
Curtiss-Wright Corp., Utica Div., Mich (l)
Dumont Corp., Calif (k,l,m)
Eljay Corp., Md (l)
Englander Co., Inc., Industrial Products Div., Md (l)
Fiber Glass Industries, Inc., NY (l)
Formica Corp., Sub. of American Cyanamid Co., Ohio (l)
Foss Mfg. Co., Id (l)
Frost Rubber Co., Ill (m)
Fry Plastics International, Calif (l)
Galigher Co., Utah (k)
Gatke Corp., Ill (l)
General American Transportation Corp., Ill (l)
General Electric Co., Plastics Dept., Ill (l)
General Tire & Rubber Co., Ind (k)
Gering Plastics Div., Studebaker-Packard Corp., NJ (k)
Glass Reinforced Plastics Corp., Ohio (l)
Glastic Corp., Ohio
(l)—Ad p 256
Greene, Tweed & Co., Pa (k,l,m)
H & R Industries, Pa (k)
Haskelite Mfg. Corp., Mich (l)
Haveg Industries, Inc., Del (l)
Hawley Products Co., Ill (l)
Hays Mfg. Co., Pa (l)
Hewitt-Robins, Inc., Conn (m)
Home Rubber Co., NJ (m)
Industrial Products Div., General Tire & Rubber Co., Ind (k)
Insulation Mfrs. Corp., Ill (k)
Kaykor Industries, Inc., Div. of Kaye-Tex Mfg. Corp., NJ (k)
Kerrco, Neb (k,l)
Knight, Maurice A., Ohio (l)
Lamtex Industries, Inc., NY (l)
Lone Star Plastics Co., Inc., Tex (l)
Lunn Laminates, Inc., NY (k,l)
Maloney, F.H. Co., Tex (l)
Marion Div., General Tire & Rubber Co., Ind (l)
Mastergias Div., Gisholt Machine Co., Wis (l)
Mechanical Rubber Products Co., NY (l)
Mica Corp., Calif (l)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (l)
Micarta Div., Westinghouse Electric Corp., SC (l)
Minnesota Mining & Mfg. Co., Reinforced Plastics Div., Minn
(l)—Ad pp 258-259
Molded Fiber Glass Co., Ohio (l)
National Vulcanized Fibre Co., Del
(l)—Ad p 249
New England Laminates Co., Inc., Conn
(l)—Ad p 281
Northwest Plastics Industries, Inc., Minn (l)
Panelyte Div., St. Regis Paper Co., NJ
(l)—Ad p 444
Penn Fibre & Specialty Co., Inc., Pa (k)
Permali, Inc., Pa
(l)—Ad p 431
Plymouth Industrial Products, Inc., Wis (k)
Porter, William Co., Calif (l)
REF Mfg. Corp., NY (l)
Reinhold Engineering & Plastics Co., Inc., Calif (l)
Ren Plastic, Inc., Mich (l)
Replac Corp., Ohio (k,l,m)
Resolite Corp., Pa (l)
Richardson Co., Ill (l)
Riverside Plastics Corp., NY (l)
Russell Reinforced Plastics Corp., NY (l)
Shamban, W.S. & Co., Ind (k)
Sierra Electric Corp., Calif (k)
Spaulding Fibre Co., Inc., NY
(l)—Ad p 255
Standard Insulation Co., NJ (l)
Stockwell Rubber Co., Inc., Pa (k,m)
Strick Plastics Co., Pa (k,l,m)
Structural Fibers, Inc., Ohio (l)
Sun Rubber Co., Ohio (m)
Swedlow, Inc., Calif
(k,l)—Ad p 263
Synthane Corp., Pa
(l)—Ad p 234
Taylor Fibre Co., Pa
(l)—Ad p 246
Thermoid Div., H.K. Porter Co., Pa (l)
Thompson, H.I. Fiber Glass Co., Calif (l)
Toledo Industrial Rubber Co., (l)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (m)
Waterbury Cos., Inc., Conn (l)
Winner Mfg. Co., Inc., NJ (l)
Wittman, Lawrence & Co., NY (k,l)
Woodall Industries, Inc., Mich (k,l)
Zenith Plastics Co., Sub. of Minnesota Mining & Mfg. Co., Calif (l)

Laminates, Metal-Metal

(incl. "bimetals"; key letters refer to base metal)

Aerojet-General Corp., Structural Materials Div., Calif (a,g,h)
Al-Fin Div., Arthur Tickle Engineering Works, Inc., NY (a,e)
Almco Steel Products Corp., Ind (g)
American Cast Iron Pipe Co., Ala (c,g)
American Silver Co., Inc., NY (b,c,f,g)
Baker & Co., Inc., NJ (b,f)
Brunswick Corp., Defense Products Div., Mich (a)
Chace, W.M. Co., Mich (a,b,c,e,f,g,h,l)
Composite Industrial Metals, Inc., RI (a,b,c,d,e,f,g,h,j)
Copperweld Steel Co., Ohio (g)
Eastern Brass & Copper Co., NY (a)
Eastern Smelting & Refining Corp., Mass (b)
Gar Precision Parts, Inc., Conn (b,f)
General Findings & Supply Co., Industrial Div., Mass (b,f)
General Plate Div., Metals & Controls Corp., Mass (a,b,c,e,f,g,h,j)
Haydon Corp., NY (a,g)
Horton-Angell Co., Mass (b,f)
Improved Seamless Wire Co., RI (b,c,f)
Knapp Mills, Inc., NY (b,g)
Laminated Shim Co., Conn (a,b,g)
Leach & Garner Co., Industrial Div., Mass (b,f)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass
(b,c,f,g)—Ad p 158
Nuclear Metals, Inc., Mass (a,b,c,e,f,g,h)
Presswork, Inc., Mich (b,d)
Revere Copper & Brass, Inc., Foil Div., NY (a)
Rockwell Engineering Co., Ill (a,b,c,g)
Rockwell-Standard Corp., Stamping Div., NY (a,b,f,g)
Standard Metals Corp., Mass (a,b,c,f,g)
Staver Co., Inc., NY (a,b)
Sylvania Electric Products, Inc., NY (b,f)
Wilson, H.A. Co., Div. of Engelhard Industries, Inc., NJ (b,f,g)
Wisconsin Gasket & Mfg. Co., Ohio (b,g)

Laminates, Metal-Organic

(key letters refer to base metal)

Aerojet-General Corp., Structural Materials Div., Calif (a,g,h)
AllianceWall Div., AllianceWare, Inc., Ohio (a,g)
American Nickeloid Co., Ill (a,g)
Arvin Industries, Inc., Ind (a,e,g)
Benjamin Electric Mfg. Co., Ill (g)
Clad-Rex Corp., Ill
(a,g)—Ad p 413
Coated Coil Corp., NY (a,g)
Cochran Foil Co., Ky (a)
Dumont Corp., Calif (a)
Enamel Products Co., Ohio (a,c)
Enamelstrip Corp., Sub. of National Steel Corp., Pa (a,b,c,f,g,j)
Gomar Mfg. Co., Inc., NJ (a)
Haydon Corp., NY (a,g)
Hood Rubber Co., Div. of B.F. Goodrich Chemical Co., Mass (a,g)
Kaiser Aluminum & Chemical Sales Inc., Ill (a)
Maloney, F.H. Co., Tex (g)
Met-L-Wood Corp., Ill (a,b,d,f,g)
New England Laminates Co., Inc., Conn (g)
Sun Steel Co., Ill (a,e,g)
Young, M.M. Div., Litho-Strip Corp., Ill (a,g)

Laminates, Wood-Metal

Brunswick Corp., Defense Products Div., Mich
Gamble Brothers, Inc., Special Products Div., Ky
Haskelite Mfg. Corp., Mich
Keller Products, Inc., NH
Laminated Veneers Co., NY
Met-L-Wood Corp., Ill
Technical Ply-Woods Sales, Ill
U.S. Plywood Corp., NY

Laminating Resins

(see specific plastic or rubber)

Lead and Its Alloys

Advance Stamping Co., Mich (dd)
Alpha Metals, Inc., NJ (n,o,v,w,z,aa,bb,cc,dd)
American Metal Climax, Inc., NY (n,o,w,aa,bb)
American Nickel Alloy Mfg. Corp., NY (w)
American Smelting & Refining Co., NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Bar-Ray Products, NY (v,z,cc)
Bearium Metals Corp., NY (w)
Belmont Smelting & Refining Works, Inc., NY (n,o,v,w,z,aa,cc,ff)
Bunker Hill Co., Calif (n,o,w,z,bb,cc,dd,ee,ff)
Cerro de Pasco Sales Corp., NY
(w)—Ad p 178
Chicago Smelting & Refining Corp., Ill (w)
Crown Metal Co., Wis (n,o,q,w,bb,cc,dd,ee,ff)
Designers Metal Corp., Ill (cc)
Dietzel Lead Burning Co., Pa (n,o,z,cc)
Division Lead Co., Ill (n,o,v,w,z,aa,cc,dd,ee,ff)
Dixie Lead Co., Tex (n,o,q,w,aa,cc)
Eagle-Picher Co., Ohio (aa)
Empire Metal Co., NY (n,o,q,v,w,z,bb,cc,dd,ee,ff)
Evans Metal Co., Ga (w,cc,ee)
Federated Metals Div., American Smelting & Refining Co., NY (n,o,w,cc,ee,ff)
Fox Products Co., Pa (n)
Glidden Co., Ind (aa)
Glidden Co., Chemical Divs., Metals Dept., Ind
(aa)—Ad p 429
Greenback Industries, Inc., Mich (aa)
Hardy, Charles, Inc., NY (aa)
Harshaw Chemical Co., Ohio (n)
Hayden Wire Works, Inc., Mass (ff)
Hayman, Michael & Co., NY (o,w)
Heil Process Equipment Corp., Ohio (n)
Hi-Grade Alloy Corp., Ill (n,o,v,w,z,bb,cc,ee,ff)
Indium Corp. of America, NY (v,cc,dd,ff)
Johnston Foil Div., Standard Packaging Corp., Mo (v,cc)
Kassel Export Co., Inc., NJ (v)
Kinkead Industries, Inc., Ill (cc,dd)
Kirk, Morris P. & Son, Calif (n,o,q,w,z,aa,bb,cc,dd)
Lavin, R. & Sons, Inc., Ill (n,w)
McGean Chemical Co., Ohio (n,o,aa,bb,dd)
Metal & Thermit Corp., NJ (n)
Metallizing Co. of Los Angeles, Inc., (ff)
Metals Disintegrating Co., Inc., NJ (aa)
National Lead Co., NY (n,o,q,w,z,aa,bb,cc,dd,ee,ff)
National Lead Construction Co., Inc., NJ (n,o,w,z,cc,ee,ff)
Nesor Alloy Products Co., NJ (ff)
New England Smelting Works, Inc., Mass (o,w)
Oatey, L.R. Co., Ohio (o,w,cc,dd)
Olds Alloy Co., Calif (q,w)
Peerless Alloy Co., Colo (n,o,q,w,z,bb,cc)
Peerless Roll Leaf Co., Div. of Howe Sound Co., NJ (v,dd)
Pittsburgh Smelting & Refining Co., Pa (o,w,cc)
Presswork, Inc., Mich (o,cc)
Republic Lead Equipment Co., Ohio (n)
Republic Metals Co., Inc., NY (n,o,q,v,w,z,cc,ee,ff)
Revere Copper & Brass, Inc., Foil Div., NY (v)
River Smelting & Refining Co., Ohio (o,w)
Rotometals, Calif (o,w,bb,cc,dd,ee,ff)
St. Joseph Lead Co., NY (w)
Sall, George Metals Co., Inc., Pa (w)
Staver Co., Inc., NY (v,cc,dd)
Stevens, Frederic B., Inc., Mich (n)
Texas Instruments, Inc., Metals & Controls Div., Mass (dd)
Udylite Corp., Mich (n)
U.S. Smelting, Refining & Mining Co., NY (w)
U.S. Stoneware Co., Ohio (n)
Waltham Foundry Co., Mass (w)

Leather and Leather Parts

Alexander Bros. Belting Co., NJ
Alexander, E.P. & Son, Mass
Auburn Mfg. Co., Conn
—Ad p 450
Bond, Charles Co., Pa
Charlotte Leather Belting Co., NC
Chicago Rawhide Mfg. Co., Ill
Chicago-Allis Mfg. Corp., Ill
Donovan, F.C., Inc., Mass
Excelsior Leather Washer Mfg. Co., Inc., Ill
Foss Mfg. Co., Id
Garlock Packing Co., NY
General Gasket, Inc., Conn
Gibb, Walton Leather Co., Pa
Glenn, Joseph & Sons, Inc., Pa
Graton & Knight Co., Mass
Haffner Bros. Co., Ohio
Hay, James E. Co., Inc., Mass
Houghton, E.F. & Co., Pa
International Packings Corp., NH
—Ad p 416
Mechanical Leathers, Inc., Pa
Michigan Leather Products Co., Mich
National Gasket & Washer Mfg. Co., Inc., NY
Norwich Leather Co., Conn
Page Belting Co., NH
Penn Fibre & Specialty Co., Inc., Pa
Porter, William Co., Calif
Rhoads, J.E. & Sons, Del
Schachner Leather & Belting Co., Charlotte Leather Belting Co. Div., NC
Shingle Leather Co., NJ
Sillcocks Miller Co., NJ
Southern Belting & Transmission Co., Ga
Standard Washer & Mat, Inc., Conn
Staver Co., Inc., NY

Truche Leather Co., Mass
Warren Belting Co., Mass
Winworth Co., Inc., NJ

Lignum Vitae

(see Wood)

Lithium

American Potash & Chemical Corp., Calif (w)
Belmont Smelting & Refining Works, Inc., NY (o,aa)
Foote Mineral Co., Pa (w)
Hardy, Charles, Inc., NY (aa)
Kawecki Chemical Co., NY (w)
Lithium Corp. of America, Inc., Minn (w,bb,ff)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)

Low Pressure Laminates

(see Laminates)

Magnesium and Its Alloys

Alabama Metallurgical Corp., Ala (w)
Aluminum Co. of America, Pa (n,o, q,z,bb,cc,dd)
Aluminum & Magnesium, Inc., Ohio (w)
American Silver Co., NY (v,dd)
American Smelting & Refining Co., NY (n,w)
Apex Smelting Co., Ill (n,w)
Arcos Corp., Pa (ff)
Armet Alloys, Inc., Ohio (n,w)
Belmont Smelting & Refining Works, Inc., NY (w)
Brooks & Perkins, Inc., Mich (z,cc,dd)
Copper & Brass Sales, Inc., Mich (o, z,bb,cc,dd,ee,ff)
Designers Metal Corp., Ill (cc)
Dow Chemical Co., Dow Metal Products Co., Div., Mich
(n,o,q,w,z,aa,bb,cc,dd,ee,ff)—Ad pp 408-409
Federated Metals Div., American Smelting & Refining Co., NY (n,w)
Hardy, Charles, Inc., NY (aa)
King Laboratories, Inc., NY (w,aa)
Kinkead Industries, Inc., Ill (cc,dd)
Light Metals, Inc., Ind (n)
Magline, Inc., Mich (o,z,bb,cc,ee,ff)
Magna Mfg. Co., Inc., NJ (aa)
Magnesium Elektron, Inc., NY (n, w,bb)
Magnode Products, Inc., Ohio (n,o,bb, dd,ee)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (o,ee)
McGean Chemical Co., Ohio (aa)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Norrich Plastics Corp., NY (o,bb)
Nuclear Metals, Inc., Mass (bb,dd,ee)
Peerless Roll Leaf Co., Div. of Howe Sound Co., NJ (v,dd)
Purdy, A.R. Co., Inc., NJ (o,z,bb,cc, ee,ff)
Reade Mfg. Co., Inc., NJ (aa)
Standard Magnesium Corp., Okla (n,q, w)
Tube Distributors Co., Inc., NY (ee)
Ullmann, Inc., Wis (o,ee)
U.S. Magnesium Div., Transition Metals & Chemicals, Inc., NY (aa)
Utica General Jobbing Foundry, Inc., NY (o)
Vanadium Corp. of America, NY (w)
Waltham Foundry Co., Mass (w)
White Metal Rolling & Stamping Corp., NY (n,o,q,z,bb,cc,dd,ee,ff)

Manganese and Its Alloys

Amalgamated Steel Corp., Ohio (o,bb)
American Nickel Alloy Mfg. Corp., NY (w)
Anaconda Co., NY (n,v,cc)
Belmont Smelting & Refining Works, Inc., NY (w,aa)
Chicago Development Corp., Md (o,v, z,bb,cc,dd,ee,ff)
Crane Co., Metals Div., Pa (aa)
Foote Mineral Co., Pa (aa)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (ff)
Hommel, O. Co., Pa (aa)
Lavin, R. & Sons, Inc., Ill (w)
Metals Disintegrating Co., Inc., NJ (aa)
National Paint & Manganese Co., Va (aa)
National-U.S. Radiator Corp., Plastic Metals Div., NY (aa)
New Jersey Zinc Co., NY (w)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Pioneer Aluminum, Inc., Calif (z)
Taylor-Wharton Co., Div. of Harsco Corp., NJ (z,bb,ff)
Tube Distributors Co., Inc., NY (ee)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
Utica General Jobbing Foundry, Inc., NY (aa)
Vanadium Corp. of America, NY (w)

Manganese Bronze

(see Copper)

Mechanical Fasteners

Abalon Precision Mfg. Corp., NY
Acme Machine Products Div., Serrick Corp., Ind
Acme Stamping & Wire Forming Co., Pa
Albany Products Co., Inc., Conn
Allen Mfg. Co., Conn
Allmetal Screw Products Co., Inc., NY
Alofs Mfg. Co., Mich
Aluminum Co. of America, Pa
American Screw Co., Conn
American Steel and Wire Div., U.S. Steel Corp., Ohio
Anti-Corrosive Metal Products Co., Inc., NY
Atlantic Steel Co., Ga
Automatic Nut Co., Pa
Automotive Rubber Co., Inc., Mich
Aviation Developments, Inc., Calif
Bethlehem Steel Co., Pa
Blake & Johnson Co., Conn
Boots Aircraft Nut Corp., Conn
Bostitch, Inc., RI
C. E. M. Co., Conn
Camloc Fastener Corp., NJ
Central Screw Co., Ill
Champion Rivet Co., Ohio
Chicago Rivet & Machine Co., Ill
Chicago Screw Co., Div. of Standard Screw Co., Ill
Cleveland Cap Screw Co., Ohio
Columbia-Geneva Steel Div., U.S. Steel Corp., Calif.
Consolidated Fruit Jar Co., NJ
Continental Screw Co., Mass
Delron Co., Inc., Calif
Dimco-Gray Co., Ohio
Driv-Lok Sales Corp., Ill
Elastic Stop Nut Corp. of America, NJ
Electric Steel Foundry Co., Ore
Erie Bolt & Nut Co., Pa
Falstrom Co., NJ
Fastex Div., Illinois Tool Works, Ill
General American Transportation Corp., Ill
General Chain & Mfg. Corp., Ohio
Gries Reproducer Corp., NY
Grip Nut Co., Ind
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Groov-Pin Corp., NJ
Harper, H.M. Co., Ill
Hartford Machine Screw Co., Div. of Standard Screw Co., Conn
Hassall, John, Inc., NY
Heli-Coil Corp., Conn
Hennefelt Precision Products, Ohio
Hi-Shear Rivet Tool Co., Calif
Holo-Krome Screw Corp., Conn
Huck Mfg. Co., Mich
Ideal Can Co., Mass
Jaques Co., Mass
Jervis Corp., Mich
K S M Products, Inc., NJ
Kinkead Industries, Inc., Ill
Klincher Locknut Corp., Ind
Langsenkamp, F.H. Co., Ind
Lincoln Iron Works, Vt
Lundquist Tool & Mfg. Co., Inc., Mass
MacLean-Fogg Lock Nut Co., Ill
—Ad p 494
Magnesium Co. of America, Ind
Magnesium Products of Milwaukee, Inc., Wis
Metal Goods Corp., Mo
Miracle Adhesives Corp., NY
Morrisville Foundry Co., Inc., Vt
National Lock Co., Fastener Div., Ill
National Machine Products Co., Mich
Navan Products, Inc., Sub. of North American Aviation Inc., Calif
Nelson Stud Welding Div., Gregory Industries, Inc., Ohio
Nutt-Shel Co., Calif
Nylok-Detroit, Mich
Ohio Nut & Bolt Co., Ohio
Palnut Co., NJ
Parker-Kalon Div., General American Transportation Corp., NJ
Penn Engineering & Mfg. Corp., Pa
Plastiglide Mfg. Corp., Calif
Plume & Atwood Mfg. Co., Conn
Prestole Corp, Ohio
Red Devil Mfg. Co., Ill
Reynolds Aluminum Supply Co., Ga
Rhode Island Tool Co., RI
Rockwell Engineering Co., Ill
Rolled Alloys, Inc., Mich
Russell, Burdsall & Ward Bolt & Nut Co., NY
—Ad p 501
Set Screw & Mfg. Co., Ill
—Ad p 496
Shakeproof Div., Illinois Tool Works, Ill
Sharon Steel Corp., Pa
Shur-Lok Corp., Calif
Sillcocks Miller Co., NJ
Simmons Fastener Corp., NY
—Ad p 497
Simonsen Metal Products Co., Ill
Snyder Mfg. Co., Inc., Ohio
Southco Div., South Chester Corp., Pa
Southern Screw Co., NC
Special Screw Products Co., Ohio
Standard Locknut & Lockwasher, Inc., Ind
Standard Pressed Steel Co., Pa
Star Expansion Industries Corp., NY
Star Stainless Screw Co., NJ
Sterling Bolt Co., Ill
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala
Thompson-Bremer & Co., Ill
Thomson, Judson L. Mfg. Co., Mass
Tinnerman Products, Inc., Ohio
Townsend Co., Engineered Fasteners Div., Pa
Tubular Rivet & Stud Co., Mass
United Shoe Machinery Corp., Mass
United-Carr Fastener Corp., Mass
Velcro Sales Corp., NY
Waldes Kohinoor, Inc., NY
Waterbury Pressed Metal Co., Conn
Waterman Industries, Inc., Calif
Weckesser Co., Ill
Wesbar Stamping Corp., Wis
Western Automatic Machine Screw Co., Div. of Standard Screw Co., Ohio
Whitehead Metal Products Co., Inc., NY
Wilson, H.A. Div., Engelhard Industries, Inc., NJ
Worth Co., Wis

Melamines

Adhesive Products Corp., NY (x)
Alcylite Plastics & Chemical Corp., Calif (p,y)
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY (p,y)
American Cyanamid Co., Plastics & Resins Div., NY
(p,x,y)—Ad pp 251-254
American-Marietta Co., Adhesive, Resin & Chemical Div., Wash (p)
Baer, N.S Co., NJ (bb,cc,dd,ee)
Booty Resineers Div., American-Marietta Co., Ohio (p)
Cadillac Plastic & Chemical Co., Mich (bb,cc,dd,ee)
Catalin Corp. of America, NY (p,x)
Colonial Kolonite Co., Ill (bb,cc,ee)
Comco Plastics, Inc., NY (bb,cc,dd, ee)
Continental-Diamond Fibre Corp., Del (bb,cc,dd,ee)
Curbell, Inc., NY (bb,cc,dd,ee)
Dapol Plastics, Inc., Mass (y)
Delta Plastics Co., NJ (bb,cc,dd,ee)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Dyna-Therm Chemical Corp., Calif (p)
Farley & Loetscher Mfg. Co., Plastics Div., Iowa (cc)
Fiberite Corp., Minn (y)
Formica Corp., Sub. of American Cyanamid Co., Ohio (bb,cc,ee)
General Electric Co., Laminated Products Dept., Ohio (bb,cc,ee)
Grigoleit Co., Ill (p,s)
Haskelite Mfg. Corp., Mich (cc,dd)
Iten Fibre Co., Ohio (bb,cc,dd,ee)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Kurz Kasch, Inc., Ohio (y)
Laminated Plastex Corp., Ohio (x,cc)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (bb,cc)
Monsanto Chemical Co., Plastics Div., Mass (p,x)
Muehlstein, H. & Co., Inc., NY (p,y)
National Vulcanized Fibre Co., Del (bb,cc,dd,ee)
Northern Plastics Corp., Wis (cc,dd)
Omni Products Corp., NY (y)
Panelyte Div., St. Regis Paper Co., NJ (x,bb,cc,dd,ee)
Penn Fibre & Specialty Co., Inc., Pa (bb,cc,dd,ee)
Philrus Products Co., NJ (bb,cc,dd,ee)
Reichhold Chemical, Inc., NY (p,x)
Richardson Co., NY (bb,cc,ee)
Sierra Electric Corp., Calif (y)
Spaulding Fibre Co., Inc., NY (bb, cc,dd,ee)
Synthane Corp., Pa (bb,cc,dd,ee)
Taylor Fibre Co., Pa (bb,cc,dd,ee)
Texas Glass Fiber Corp., Tex (y)
U.S. Polymeric Chemical, Inc., Conn (s)
Westlake Plastics Co., Pa (bb,cc,dd,ee)

Metal Powder Parts

(Metal Compacts)

Allied Products Corp., Mich (c)
Aluminum Co. of America, Pa (a)
American Brake Shoe Co., NY (a,b,c, f,g,)
American Nickel Alloy Mfg. Corp., NY (f)
American Powdered Metals, Inc., Conn (b,c)
American Sinteel Corp., NY (b,c,d,g)
American Sinterings Div., Engineered Plastics, Inc., Conn (b,c,f,g,j)
Amplex Div., Chrysler Corp., Mich (b,c,f,g)
Arnold Engineering Co., Ill (c,f)
Arrow Sintered Products Co., Ill (b, c,g)
Asco Sintering Corp., Calif (a,b,c,d,f,g)
Atlas Brass Foundry, Calif (b,c)
Bassick Co., Conn (a,b,c,f,g)
Bendix Aviation Corp., NJ (a,b,c,f,g)
Boston Gear Works, Mass (a,b,c,f,g)
Bound Brook Oil-Less Bearing Co., NJ (b,c,f)
Brockway Pressed Metals, Inc., Pa (a, b,c,f,g)
Bunting Brass & Bronze Co., Ohio (b,c)
Burgess-Norton Mfg. Co., Ill (a,b,c,f, g)
Ceromet, Inc., Calif (b,c,f,g)
Chicago Development Corp., Md (h)
Chicago Powdered Metals Products Co., Ill (a,b,c,f,g)
Cleveland Graphite Bronze Co., Ohio (a,b,c,f,g)
Compacted Metals Corp., Ill (b,c,f,g)
CrystalX Corp., Pa (bb,cc,dd,ee)
Delco Moraine Div., General Motors Corp., Ohio (b,c,f,g)
Diamond Mfg. Co., Pa (a,b,f,g)
Dixon Sintaloy, Inc., Conn (b,c,f,g,h,j)
Eaton Mfg. Co., Powdered Metals Div., Mich (b,c,d,f,g,j)
Eberhart Steel Products, Powdered Metals Div., Ind (b,c)
Engineered Plastics & American Sinterings, Inc., Conn (b,c,f,g)
Ferro Powdered Metals, Inc., Ind (b, c,f,g)
General Metals Powder Co., Ohio (b, c,d,j)
General Powdered Metal Products, Inc., Holly Corp., Conn (a,b,c,f,g)
General Sintering Corp., Ill (a,b,c,f,g)
Gibson Electric Co., Pa (a,b,c,f)
Haller, Inc., Mich (b,c,g)
Indar Corp., Ind (a,b,c,f,g)
Indiana Steel Products Co., Ind (a, b,c,f,g)
International Powder Metallurgy Co., Inc., Pa (a,b,c,d,f,g,j)
Johnson Bronze, Pa (b,c)
Keystone Carbon Co., Pa (b,c,f,g)
Kwikset Powdered Metal Products, Calif (b,c,d,f,g)
Lux Clock Mfg. Co., Inc., Conn (a, b,c,f,g)
Magnetic Core Corp., NY (c)
Mallory, P.R. & Co., Inc., Ind (g)
Merriman Bros., Inc., Mass (b,c,f,g)
Metal Powder Products, Inc., Ohio (b, c,g)
Metals Disintegrating Co., Inc., NJ
(a,b,c,f,h,j)—Ad p 456
Micro Metallic Corp., NY (a,b,c,f,g)
Micro-Metals Co., Calif (a,b,c,e,f)
Midwest Sintered Products Corp., Ill (b,c)
Mueller Brass Co., Mich
(a,b,c,f,g)—Ad p 455
National Molded Products, Inc., Pa (a,b,c,f,g)
National Moldite Co., NJ (c)
Norwalk Powdered Metals, Inc., Conn (b,c,f,g,j)
Nuclear Metals, Inc., Mass (a,b,c,e,f, g,h)
Pacific Sintered Metals Co., Calif (b, c)
Parker White Metal Co., Pa (b,c,f,g)
Picco, Inc., Calif (c)
Powder Metals Products Co., Pa (a, b,c,f,g)
Powdercraft Corp., SC (a,b,c,f,g)
Precision Metal Products Co., Pa (b,c)
Presmet Corp., Mass (b,c,f,g,j)
Pure Carbon Co., Inc., Pa (c)
Raybestos Div., Raybestos-Manhattan, Inc., Conn (a,b,c,e,f,h)
Reese Metal Products Corp., Pa (b,c,g)
Republic Steel Corp., Ohio (c)
Russell Mfg. Co., Conn (b)
St. Marys Carbon Co., Pa (b,c,f)
Schwarzkopf Development Corp., NY (a,b,c,e,f)
Sintercast Div., Chromalloy Corp., NY (a,b,c,f,g)
Sintered Metals, Inc., Mass (b,c)
Sparta Foundry Div., Muskegon Piston Ring Co., Mich (b,c)
Star Heel Plate Co., Inc., NJ (c)
Superior Carbon Products, Inc., Ohio (b,c,f,g)
Supermet Div., Globe Industries, Inc., Ohio
(c,f,g)—Ad p 464
Torrington Co., Conn (a,b,f,g)
United Sintered Alloys, NY (a,b,c,f,g)
U.S. Graphite Co., Div. of Wickes Corp., Mich (b,c,d,f,g,j)
Unlworld Research Corp. of America, Ohio (c,f)
Veremere, E.A., Inc., Calif (a,b,c,f,g)
Wakefield Bearing Corp., Mass (b,c, f,g,h,j)
Wellman, S.K. Co., Ohio (b,c)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (a,b,c,f,g,h)
Yale & Towne Mfg. Co., Powdered Metal Products Div., Ill (b,c)

Metallic Coatings

(see Diffusion Coatings; Immersion Coatings; Galvanizers; Electroplaters; Hard Facing Alloys; Preplated Metals; Metallized Coatings)

Metallized Coatings—Spray Metallizers

Alloy Products Corp., Wis
American Metal Products Co., Mich
Applied Instruments, Inc., NY
Bisonite Co., Inc., NY
Continental Boiler & Sheet Iron Works, Mo
Elmet Div., North American Phillips Co., Inc., Me
Farwell Metal Fabricating, Minn
Flood City Brass & Electric Co., Pa
Hayden Wire Works, Inc., Mass
Haynes Stellite Co., Div. of Union Carbide Corp., Ind
Jema-American, Inc., NJ
Linde Co., Div. of Union Carbide Corp., NY
McGregor-Michigan Corp., Mich
Metal-Cladding, Inc., NY
Metallizing Co. of America, Ill
Metallizing Co. of Los Angeles, Inc., Calif
Metallizing Engineering Co., Inc., NY
—Ad pp 351, 360
Metalweld, Inc., Pa
Moore Dry Dock Co., Calif
New Jersey Zinc Co., NY
Parker White Metal Co., Pa
Sandy Hill Iron & Brass Works, NY
Schori Process Div., Ferro-Co Corp., NY
Schwartz Chemical Co., Inc., NY
Southern Galvanizing Co., Md
Superior Plating, Inc., Minn
Tickle, Arthur Engineering Works, Inc., NY
Wall Colmonoy Corp., Stainless Process Div., Mich
Waterbury Cos., Inc., Conn
Zeller Corp., Ohio

Metallized Coatings—Vacuum Metallizers

Adams Plastic Products, Ohio
American Metal Climax, Inc., NY
American Metal Products Co., Mich
Amos Molded Plastics Div., Amos-Thompson Corp., Ind
Applied Instruments, Inc., NY
Bee Chemical Co., Ill
Closures, Inc., Conn
Coating Products, Inc., NJ
—Ad p 359
Cohan Epner Co., Inc., NY
Consolidated Vacuum Corp., NY
Cruver Mfg. Co., Ill
Davis Products Corp., NY
Dobeckmun Co., Div. of Dow Chemical Co., Ohio
Electrolizing Co., Ill
Electronic Parts Mfg. Co., Inc., NJ
Erie Resistor Corp., Plastics Div., Pa
Eyelet Specialty Div., International Silver Co., Conn
Gomar Mfg. Co., Inc., NJ
Hastings & Co., Inc., Pa
High Vacuum Equipment Corp., Mass
Industrial Paint Div., Glidden Co., Ohio
International Optical Co., Inc., NY
Jema-American, Inc., NJ
Kinney Mfg. Div., N.Y. Air Brake Co., Mass
Libbey - Owens - Ford Glass Co., Liberty Mirror Div., Pa
—Ad p 358
Metallizing Co. of America, Ill
Metaplast Process, Inc., NY
Optical Coating Laboratory, Inc., Calif
Owens-Illinois Glass Co., Closure & Plastics Div., Ohio
Poly-Kote, Inc., Mass
St. Eloi Corp., Ohio
Schwartz Chemical Co., Inc., NY
Shelby Instrument Co., Calif
Stokes, F.J. Corp., Pa
Superior Plastics, Inc., Ill
Swedlow, Inc., Calif
—Ad p 263
Sylvania Electric Products, Inc., NY

Metallized Coatings—Metallizing Wire

Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa
Alloy Metal Wire Co., Inc., Pa
Alphaloy Corp., Div. of Alpha Metals, Inc., Ill
Belmont Smelting & Refining Works, Inc., NY
Carpenter Steel Co., Webb Wire Div., NJ
Colonial Alloys Co., Pa
Crucible Steel Co. of America, Pa
Electronic Parts Mfg. Co., Inc., NJ
Elmet Div., North American Phillips Co., Inc., Me
Empire Metal Co., NY
Hayden Wire Works, Inc., Mass
Marlane Development Co., Inc., NY
Metal Goods Corp., Mo
Metallizing Co. of America, Ill
Metallizing Co. of Los Angeles, Inc., Calif
Metallizing Engineering Co., Inc., NY
—Ad pp 351, 360
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa
Roebling's, John A. Sons Div., Colorado Fuel & Iron Corp., NJ
Rotometals, Calif
Sandvik Steel, Inc., NJ
Stainless and Strip Div., Jones & Laughlin Steel Corp., Mich
Superior Mfg. Co., Pa
United Refining & Smelting Co., Ill
unlworld Research Corp. of America, Ohio
Vanadium-Alloys Steel Co., Pa
White Metal Rolling & Stamping Corp., NY
Wright Metalcoaters, NJ

Methyl Methacrylate

(see Acrylic Plastics)

Mica

Asheville-Schoonmaker Mica Co., Va (r,z,aa,cc,ee)
Beryl Ores Co., Colo (z,aa,cc)
Concord Mica Corp., NH (aa)
Continental-Diamond Fibre Corp., Del (r,z,cc,ee)
Edgar Plastic Kaolin Co., Fla (aa)
Farnam Mfg. Co., NC (r)
Foote Mineral Co., Pa (aa)
Franklin Mineral Products Co., NC (aa)
Funkhouser Mills, Div. of Ruberoid Co., Md (aa)
General Electric Co., NY (r)
Hall, C.P. Co., Ohio (aa)
Haveg Industries, Inc., Del
(bb,cc)—Ad pp 425-426
Hayden Mica Co., Inc., Mass (aa)
Industrial Mica Corp., NJ (cc)
Insulation Mfrs. Corp., Ill (r,cc,ee)
Kassel Export Co., Inc., NJ (bb,ee)
McGean Chemical Co., Ohio (aa)
Mica Fabricating Co., NJ (r,aa,cc)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (z,cc,ee)
Micacraft Products, Inc., NJ (r,cc)
Mycalex Corp. of America, NJ
(r,z,aa,bb,cc,dd)—Ad pp 323-326
Peerless Products Industries, Ill (r)
Richmond Mica Corp., Va (aa)
Smith Chemical & Color Co., Inc., NY (aa)
Sylvania Electric Products, Inc., Parts Div., Pa (r)

Synthetic Mica Co., Div. of Mycalex Corp. of America, NJ (aa)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
U.S. Mica Co., Inc., Ill (r)

Mineral Wool

(see Inorganic Fibers)

Molding Compounds

(see specific plastic or rubber)

Moldings, Blow

Adams Plastic Products, Ohio (k)
American Can Co., Plastics Div., NY (k)
American Hard Rubber Co., Div. of Amerace Corp., NJ (l)
Amos Molded Plastics Div., Amos-Thompson Corp., Ind (k)
Artmor Plastics Corp., Md (k)
Brown Rubber Co., Inc., Ind (m)
Cadillac Plastic & Chemical Co., Mich (k)
CrystalX Corp., Pa (k)
Davis, Joseph Plastics Co., NJ (k)
Eclipse Plastic Industries, Inc., Fla (k)
Foster Grant Co., Mass (k)
General Plastics Corp., Ind (k)
General Plastics Mfg. Co., Wash (k,m)
Hohwieler Rubber Co., Inc., Pa (m)
Johnson Rubber Co., Ohio (m)
Lee Rubber & Tire Corp., Pa (m)
Lus-Trus Corp., Mich (k)
Luzerne Rubber Co., NJ (l)
Madin Plastics Inc., NJ (k)
Naige Co., Inc., NY (k)
Newth Rubber Co., RI (m)
Owens-Illinois Glass Co., Closure & Plastics Div., Ohio (k)
Plax Corp., Conn (k)
Rogers Corp., Conn (m)
Schwab Plastic Corp., Mich (k,m)
Seamless Rubber Co., Conn (m)
Shamban, W.S. & Co., Calif (k)
Sheller Mfg. Corp., Mich (l,m)
Shoe Form Co., Inc., DeWitt Plastics Div., NY (k)
Stockwell Rubber Co., Inc., Pa (m)
Stokes Molded Products Div., Electric Storage Battery Co., NJ (l)
Sun Rubber Co., Ohio (m)
Swedlow Inc., Calif (k,l)
Tuff Clad, Inc., Ohio (k)
Universal Unlimited, Inc., NY (k)
Wasco Products, Inc., Mass (k)
Western Felt Works, Ill (l,m)
Westlake Plastics Co., Pa (k)
Whyte Mfg. Co., Inc., NY (k,m)
Woodall Industries Inc., Mich (k)

Moldings, Cold

Acushnet Process Co., Mass (m)—Ad p 448
American Hard Rubber Co., Div. of Amerace Corp., NJ (l)
American Insulator Corp., Pa (l)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Biggs, Carl H. Co., Inc., Calif (l)
Calfibe, Co., Inc., Calif (l)
Ceilcote Co., Ohio (l)
Dryden Rubber Div., Sheller Mfg. Co., Ill (m)
Dumont Corp., Calif (l)
Enflo Corp., NJ (l)
Foss Mfg. Co., Id (l)
Garfield Mfg. Co., NJ (l)
Garlock Packing Co., NY (k,m)
Halex Corp., Mich (k)
Heil Process Equipment Corp., Ohio (l)
Hohwieler Rubber Co., Inc., Pa (m)
Modern Industrial Plastics Div., Duriron Co., Ohio (l)
Raybestos Div., Raybestos-Manhattan, Inc., Conn (l)
Rostone Corp., Ind (l)
Seamless Rubber Co., Conn (m)
Schori Process Div., Ferro-Co Corp., NY (l)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (k)
U.S. Gasket Plastics Div., Garlock Packing Co., NJ (l)
Warminster Fiberglass Co., Div. of Fischer & Porter Co., Pa (l)

Moldings, Compression

Acadia Synthetic Products Div., Western Felt Works, Ill (m)—Ad p 412
Ackerman Plastic Molding Div., Consolidated Iron-Steel Mfg. Co., Ohio (l)
Acushnet Process Co., Mass (m)—Ad p 448
Admiral Corp., Molded Products Div., Ill (l)
Aerojet-General Corp., Structural Materials Div., Calif (l)
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (l)
Alcylite Plastics & Chemical Corp., Calif (l)
Allegheny Plastics, Inc., Pa (k)
Allied Resinous Products, Inc., Ohio (k)
American Agile Corp., Ohio (k)
American Hard Rubber Co., Div. of Amerace Corp., NJ (k,l,m)
American Insulator Corp., Pa (l)
American Plastics Corp., NY (l)
American Sinterings Div., Engineered Plastics, Inc., Conn (l)
Anderson Assoc., Inc., Ohio (l)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Aries Laboratories, Inc., Conn (l)
Armstrong Cork Co., Pa (l)
Artmor Plastics Corp., Md (k)
Atlantic India Rubber Works, Inc., Ill (m)
Auburn Mfg. Co., Conn (k,m)—Ad p 450
Auburn Plastics, Inc., NY (k,l)
Automotive Rubber Co., Inc., Mich (m)
Bangor Plastics Inc., Mich (l)
Beck, I. & Sons, Inc., NY (k)
Belko Corp., Md (m)
Boonton Molding Co., NJ (k)
Bolta Products Div., General Tire & Rubber Co., Mass (l)
Button Corp. of America, NJ (l)
Cadillac Plastic & Chemical Co., Mich (k)
Camfield Fiberglass Plastics, Inc., Mich (l)
Canfield, H.O. Co., Va (l,m)
Capac Mfg. Corp., Mich (l,m)
Chemtrol, Calif (k)
Chicago Gasket Co., Ill (l)
Chicago Molded Products Corp., Ill (l)
Chicago Molded Products Corp., Custom Molding Div., Ill (l)
Chicago Rawhide Mfg Co., Ill (k,m)
Chicago-Allis Mfg. Corp., Ill (m)
Colonial Rubber Co., Div. of U.S. Stoneware Co., Ohio (k,m)—Ad p 441
Colt's Plastics Co., Inc., Conn (l,m)
Conneaut Rubber & Plastics Co., Div., of U.S. Stoneware Co., Ohio (k,l,m)
Connecticut Hard Rubber Co., Conn (m)
Consolidated Molded Products Corp., Pa (l)
Continental Rubber Works, Pa (m)
Continental-Diamond Fibre Corp., Del (k,l)
Crane Packing Co., Ill (k)
Curtiss-Wright Corp., Plastics Div., NY (l)
Curtiss-Wright Corp., Utica Div., Mich (l)
Davidson Rubber Co., Mass (l,m)
Dayton Rubber Co., Ohio (m)
Delta Plastics Co., NJ (l)
Dimco-Gray Co., Ohio (l)
Disogrin Industries, Inc., NY (m)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (k)
Dumont Corp., Calif (l)
Duriron Co., Inc., Ohio (l)
Electronic Production & Development, Inc., Chemical Div., Calif (l)
Enflo Corp., NJ (l)
Fabricon Products Div., Eagle-Picher Co., Mich (l)
Faultless Rubber Co., Ohio (m)
Fiber Glass Industries, Inc., NY (l)
Fibercast Div., Youngstown Sheet & Tube Co., Okla (l)
Fiberglass Ohio Inc., Ohio (l)
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass (l,m)
Firestone Tire & Rubber Co., Ohio (m)
Garfield Mfg. Co., NJ (l)
Garlock Packing Co., NY (k,m)
Gatke Corp., Ill (l)
Geauga Industries Co., Ohio (m)
General American Transportation Corp., Ill (k,l)
General American Transportation Corp., Plastics Div., Ill (k,l)—Ad p 411
General Electric Co., Chemical & Metallurgical Div., Ill (l)
General Electric Co., Plastics Dept., Ill (l,m)
General Gasket, Inc., Conn (m)
General Industries Co., Molded Plastic Div., Ohio (l)
Glass Reinforced Plastics Corp., Ohio (l)
Glastic Corp., Ohio (l)
Goodrich, B.F. Industrial Products Co., Ohio (k)
Goshen Rubber Co., Inc., Ind (m)—Ad p 438
Greene, Tweed & Co., Pa (k,l,m)
Grimes Mfg. Co., Plastic Research Products Div., Ohio (l)
Halogen Insulator & Seal Corp., Ill (l)
Haveg Industries, Inc., Del (l)—Ad pp 425-426
Hawkeye Rubber Mfg. Co., Iowa (m)
Hawley Products Co., Ill (l) (m)
Hays Mfg. Co., Pa (l)
Hohwieler Rubber Co., Inc., Pa (m)
Industrial Molded Products Co., Inc., Ill (l)
Industrial Products Div., General Tire & Rubber Co., Ind (m)
Insulation Products Co., Pa (l)
International Packings Corp., NH (m)—Ad p 416
Jersey Plastic & Die Casting Co., NJ (l)
Johnson Rubber Co., Ohio (m)
Judsen Rubber Works, Inc., Ill (m)
Kerrco, Neb (k,l)
Kirkhill Rubber Co., Calif (m)
Kuhn & Jacob Molding & Tool Co., NJ (l)
Kurz Kasch, Inc., Ohio (l)
Lamtex Industries, Inc., NY (l)
Lavelle Rubber Co., Ill (m)
Lee Rubber & Tire Corp., Pa (m)
Lewis, G.B. Co., Wis (l)—Ad p 432
Lone Star Plastics Co., Inc., Tex (l)
Loranger Mfg. Corp., Pa (l)
Lunn Laminates, Inc., NY (l)
Luzerne Rubber Co., NJ (k,l)
Mack Molding Co., NJ (l)
Maloney, F.H. Co., Tex (l,m)
Martin Rubber Co., Inc., NJ (m)
Mesa Plastics Co., Calif (l)
Micarta Div., Westinghouse Electric Corp., SC (k,l,m)
Mid-States Rubber Products, Inc., Ind (m)
Midwest Molding & Mfg. Co., Ill (l)
Midwest Rubber Co., Mich (m)
Minneapolis Plastic Molders, Inc., Minn (l)
Minnesota Rubber Co., Minn (m)
Modern Industrial Plastics Div., Duriron Co., Ohio (l)
Modern Plastics Corp., Mich (l)
Molded Fiber Glass Co., Ohio (l)
Morrell, George Corp., Mich (l)
Moxness Products, Inc., Wis (l,m)—Ad p 460
National Lock Co., Ill (l)
Newth Rubber Co., RI (m)
Owens-Illinois Glass Co., Closure & Plastics Div., Ohio (l)
Pacific Moulded Products Corp., Calif (m)
Paeco Rubber Co., Inc., Ohio (k,l,m)
Panelyte Div., St. Regis Paper Co., NJ (l)
Parker Appliance Co., Rubber Products Div., Ohio (m)
Parker Seal Co., Div. of Parker-Hannifin Corp., Calif (m)
Parker, Stearns & Co., Inc., NY (m)
Perry Plastics, Inc., Pa (k,l)
Plastic Masters, Inc., Mich (l)
Plastic Products Corp., Ohio (l)
Plasticrafters, Inc., Ill (l)
Precision Rubber Products Corp., Ohio (m)
Raybestos-Manhattan, Inc., NJ (l,m)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Regal Plastic Co., Mo (l)
Reinhold Engineering & Plastics Co., Inc., Calif (l)
Resistoflex Corp., NJ (k)
Richardson Co., NY (l)
Riverside Plastics Corp., NY (l)
Roberts Toledo Rubber Co., Ohio (m)
Rogers Corp., Conn (l,m)
Rogers, V.F. Plastic Molding, Colo (l,m)
Romar Plastics, Inc., Ill (l)
Rostone Corp., Ind (l)
Roth Rubber Co., Ill (l,m)
Russell Reinforced Plastics Corp., NY (l)
St. Clair Rubber Co., Mich (m)
Sealview Plastics, Inc., Pa (l)
Shamban, W.S. & Co., Calif (k)
Shaw Insulator Co., NJ (l)
Sheller Mfg. Corp., Mich (k,l,m)
Sierra Electric Corp., Calif (l)
Sierra Engineering Co., Calif (m)
Sillcocks Miller Co., NJ (k)
Southern Plastics Co., SC (l)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (k)
Spencer Rubber Co., Conn (m)
Stalwart Rubber Co., Ohio (m)
Standard Plastics Co., Mass (l)
Stillman Rubber Co., Calif (m)
Stockwell Rubber Co., Inc., Pa (k,l,m)
Stokes Molded Products Div., Electric Storage Battery Co., NJ (l)
Stowe-Woodward, Inc., Mass (m)
Structural Fibers, Inc., Ohio (l)
Sun Rubber Co., Ohio (m)
Swedish Crucible Steel Co., Mich (k)
Swedlow, Inc., Calif (l)
Sylvania Electric Products, Inc., Parts Div., Pa (l)
Synthane Corp., Pa (l)
Taunton Div., Haveg Industries, Inc., Mass (k,l,m)
Texstar Plastics Div., Texstar Corp., Tex (k,l)
Thermoid Div., H.K. Porter Co., Pa (l)
Tingley Rubber Corp., NJ (m)
Toledo Industrial Rubber Co., Ohio (l,m)
Toyad Corp., Pa (k,m)
Trostel, Albert Packing, Ltd., Wis (m)
Tyer Rubber Co., Mass (m)
U.S. Gasket Plastics Div., Garlock Packing Co., NJ (k,l)
U.S. Rubber Co., Mechanical Goods Div., Ind (l)
U.S. Stoneware Co., NY (k,l)
Vulcanized Rubber & Plastics Co., Pa (m)
Waldman, Joseph & Sons, Epoxy Products Div., NJ (l)
Warminster Fiberglass Co., Div. of Fischer & Porter Co., Pa (l)
Waterbury Cos., Inc., Conn (l)
Wesbar Stamping Corp., Wis (m)
Western Felt Works, Ill (l,m)
Westlake Plastics Co., Pa (k)
Whitso, Inc., Ill (l)
Williams - Bowman Rubber Co., Ill
(l,m)—Ad p 276
Wittman, Lawrence & Co., NY (l)
Woodall Industries, Inc., Mich (k,l)
Wyatt Industries Inc., Plastic & Rubber Div., Tex (l,m)
Yale Rubber Mfg. Co., Mich (m)
Zenith Plastics Co., Calif (l)

Moldings, Injection

aaRBee Plastic Co., Calif (k)
Acushnet Process Co., Mass
(m)—Ad p 448
Adams Plastic Products, Ohio (k)
Admiral Corp., Molded Products Div., Ill (k)
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (k)
American Agile Corp., Ohio (k)
American Can Co., Plastics Div., NY (k)
American Hard Rubber Co., Div. of Amerace Corp., NJ (k,m)
American Insulator Corp., Pa (k,m)
American Plastics Corp., NY (k)
Amos Molded Plastics Div., Amos-Thompson Corp., Ind (k)
Anderson Assoc., Inc., Ohio (k)
Anthes Div., Gleason Corp., Iowa (k,l)
Armstrong Cork Co., Pa (k)
Auburn Mfg. Co., Conn
(k,m)—Ad p 450
Auburn Plastics, Inc., NY (k,m)
Auburn Rubber Co., Inc., Ind (k)
Belko Corp., Md (m)
Bolta Products Div., General Tire & Rubber Co., Mass (k)
Booker & Wallestad, Inc., Minn (k)
Boonton Molding Co., NJ (k)
Bridgeport Moulded Products, Inc., Conn (k)
Buckeye Molding Co., Ohio (k)
Burwood Products Co., Mich (k)
Byrd Plastics, Inc., Pa (k)
Cambridge-Panelyte Molded Plastics Co., Div. of St. Regis Paper Co., Ohio (k)
Campro Co., Ohio (k)
Canfield, H.O. Co., Va (l,m)
Carlon Products Corp., Ohio (k)
Celluplastic Corp., NJ (k)
Chemtrol, Calif (k)
Chicago Molded Products Corp., Ill (k)
Cnicago Molded Products Corp., Custom Molding Div., Ill (k)
Chicago-Allis Mfg. Corp., Ill (m)
Clover Industries, Inc., NY (k)
Colonial Plastics Mfg. Co., Div. of Van Dorn Iron Works Co., Ohio (k)
Colt's Plastics Co., Inc., Conn (k)
Comet Metal Products Co., Inc., NY (k)
Commercial Plastics Co., Ill (k)
Commercial Plastics Co., Associated Plastic Div., Mich (k)
Conneaut Rubber & Plastics Co., Div. of U.S. Stoneware Co., Ohio (k,l,m)
Consolidated Molded Products Corp., Pa (k)
Continental Rubber Works, Pa (m)
Continental-Diamond Fibre Corp., Del (k)
Cosmo Plastics Co., Ohio (k)
Cruver Mfg. Co., Ill (k)
CrystalX Corp., Pa (k)
Curtiss-Wright Corp., Plastics Div., NY (k)
Danielson Mfg. Co., Conn (k)
Dapol Plastics, Inc., Mass (k,l)
Dayton Rogers Mfg. Co., Minn (k,l)
Delta Plastics Co., NJ (k)
Denver Plastics, Inc., Colo (k)
Detroit Macoid Corp., Mich (k,m)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (k,m)
Electronic Production & Development, Inc., Chemical Div., Calif (k)
Engineered Nylon Products Div., Kennatrack Corp., Ind (k)
Erie Resistor Corp., Plastics Div., Pa (k)
Fabricon Products Div., Eagle-Picher Co., Mich (k)
Federal Tool Corp., Ill (k)
Fiberglass Ohio Inc., Ohio (l)
Foster Grant Co., Mass (k)
Franklin Plastics, Inc., Pa (k)
Fry Plastics International, Calif (k)
Galigher Co., Utah (k,l)
Garlock Packing Co., NY (k)
Geauga Industries Co., Ohio (m)
General American Transportation Corp., Ill (k)
General American Transportation Corp., Plastics Div., Ill
(k)—Ad p 411
General Electric Co., Chemical & Metallurgical Div., Ill (k)
General Electric Co., Plastics Dept., Ill (k)
General Industries Co., Molded Plastic Div., Ohio (k)
Glass Laboratories, Inc., NY (k)
Goodrich, B.F. Industrial Products Co., Ohio (k)
Gossett and Hill Co., Ill (k)
Gotham Plastics Corp., NY (k)
Gries Reproducer Corp., NY (k)
H & R Industries, Pa (k)
Hauser Products, Inc., Ill (l)
Hewitt-Robins, Inc., Conn (m)
Hungerford Plastics Corp., NJ (k,m)
Industrial Molded Products Co., Inc., Ill (k)
Industrial Products Div., General Tire & Rubber Co., Ind (k)
Jamison Plastic Corp., NY (k)
Jersey Plastic & Die Casting Co., NJ (k)
Jet Specialties Co., Inc., Calif (k)
Johnson Plastic Corp., Ohio (k,m)
Judsen Rubber Works, Inc., Ill (m)
Keolyn Plastics, Inc., Ill (k)
Kerrco, Neb (k,l)
Kirk, F.J. Co., Inc., Mass (k)
Lancaster Glass Corp., Ohio (k)
Lee Rubber & Tire Corp., Pa (m)
Lincoln Molded Plastics, Inc., Ohio (k)
Lone Star Plastics Co., Inc., Tex (k)
Loranger Mfg. Corp., Pa (k)
Luminous Resins, Inc., Ill (k)
Luzerne Rubber Co., NJ (k)
Mack Molding Co., NJ (k)
Madin Plastics Inc., NJ (k)
Mallory, P.R. Plastics, Inc., Ill (k)
Maloney, F.H. Co., Tex (k)
Michigan Plastic Products, Inc., Mich (k)
Midwest Molding & Mfg. Co., Ill (k)
Minneapolis Plastic Molders, Inc., Minn (k)
Minnesota Plastics Corp., Minn (k,m)
Minnesota Rubber Co., Minn (m)
Modern Industrial Plastics Div., Durion Co., Ohio (k)
Modern Plastics Corp., Mich (k)
Moxness Products, Inc., Wis
(k)—Ad p 460
Mueller Brass Co., Mich
(k)—Ad p 455
Nalge Co., Inc., NY (k)
National Lock Co., Ill (k)
Norgren-Stemac, Inc., Colo (k)
Nosco Plastics Co., Pa (k)
Nylon Molded Products Corp., Ohio (k)
Nyloncraft, Inc., Ind (k)
Ohio Rubber Co., Ohio (k)
O'Sullivan Rubber Corp., Va (k)
Owens-Illinois Glass Co., Closure & Plastics Div., Ohio (k)
Paeco Rubber Co., Inc., Ohio (k,l,m)
Panelyte Div., St. Regis Paper Co., NJ (k)
Parker Seal Co., Div. of Parker-Hannifin Corp., Calif (m)
Pee Wee Molding Corp., NY (k)
Peoria Plastic Co., Ill (k)
Perfex Plastics, Inc., Ill (k)
Perry Plastics, Inc., Pa (k,l)
Pipco International Corp., Sub. of Plastiglide Mfg. Corp., Calif (k)
Plastic Engineering, Inc., Ohio (k)
Plastic Masters, Inc., Mich (k)
Plasticrafters, Inc., Ill (k,m)
Plastiglide Mfg. Corp., Calif (k)
Plax Corp., Conn (k)
Plymouth Industrial Products, Wis (k)
Porter, William Co., Calif (k)
Precision Plastics Co., Pa (k)
Prince Rubber & Plastics Products, Inc., NY (k,l)
Pyramid Products Co., Inc., Ohio
(k)—Ad p 458
Pyro Plastics Corp., NJ (k)
Quinn-Berry Corp., Pa (k)
Raybestos-Manhattan, Inc., NJ (m)
Roberts Toledo Rubber Co., Ohio (m)
Rogers, V.F. Plastic Molding, Colo (k)
Romar Plastics, Inc., Ill (k)
St. Clair Rubber Co., Mich (m)
Sanford Plastics Corp., NY (k)
Santay Corp., Ill (k)
Saran Lined Pipe Co., Div. of Michigan Pipe Co., Mich (k)
Schaefer-Hausner Corp., NY (k)
Schwab Plastic Corp., Mich (k)
Shamban, W.S. & Co., Calif (k)
Shaw Insulator Co., NJ (k)
Sheller Mfg. Corp., Mich (k,l,m)
Sierra Electric Corp., Calif (k)
Sillcocks Miller Co., NJ (k)
Sinko Mfg. & Tool Co., Ill (k)
Standard Plastics Co., Mass (k)
Sterling Molders, Inc., NY (k)
Stockwell Rubber Co., Inc., Pa (m)
Stokes Molded Products, Div. of Electric Storage Battery Co., NJ (l)
Superior Plastics, Inc., Ill (k)
Sylvania Electric Products, Inc., Parts Div., Pa (k)
Taunton Div., Haveg Industries, Inc., Mass (k)
Tingley Rubber Corp., NJ (k)
Toledo Industrial Rubber Co., Ohio (l,m)
Tri-State Plastic Molding Co., Ky (k)
Tube Turns Plastics, Inc., Ky (k)
U.S. Gasket Plastics Div., Garlock Packing Co., NJ (k)
U.S. Rubber Co., Mechanical Goods Div., Ind (k)
United-Carr Fastener Corp., Mass (k,l)
Vulcanized Rubber & Plastics Co., Pa (k,m)
Wagner Plastic Corp., NJ (k)
Waterbury Cos., Inc., Conn (k)
Western Felt Works, Ill (l,m)
Westlake Plastics Co., Pa (k)
Whyte Mfg. Co., Inc., NY (k,m)
Worcester Moulded Plastics Co., Mass (k)
Zenith Plastics Co., Calif (l)

Moldings, Reinforced Plastics

(see Laminates)

Moldings, Sheet

(sheet formed parts)

Aerojet-General Corp., Structural Materials Div., Calif (l)
Allied Resinous Products, Inc., Ohio (k)
American Agile Corp., Ohio (k)
American Hard Rubber Co., Div. of Amerace Corp., NJ (k,l)
American Plastics Corp., NY (k)
American Polyglas Corp., NJ (l)
Amos Molded Plastics Div., Amos-Thompson Corp., Ind (k)
Artmor Plastics Corp., Md (k)
Auburn Rubber Co., Inc., Ind (k)
Blank, Arthur & Co., Inc., Mass (k)
Borkland Mfg. Co., Ind (k)
Brown Rubber Co., Inc., Ind (m)
Cadillac Plastic & Chemical Co., Mich (k,l)
Cambridge-Panelyte Molded Plastics Co., Div. of St. Regis Paper Co., Ohio (k)
Canfield, H.O. Co., Va (l,m)
Carolina Industrial Plastics Div., Essex Wire Corp., NC (k)
Carroll, J.B. Co., Ill (k)
Chicago-Allis Mfg. Corp., Ill (m)
Cincinnati Industries Inc., Ohio (k)
Colonial Art Co., Inc., Mass (k)
Colonial Rubber Co., Div. of U.S. Stoneware Co., Ohio
(k,m)—Ad p 441
Connecticut Hard Rubber Co., Conn (m)
Consolidated Molded Products Corp., Pa (k)
Continental Rubber Works, Pa (m)
Continental-Diamond Fibre Corp., Del (k,l)
CrystalX Corp., Pa (k)
Curbell, Inc., NY (k)
Duplican Corp., Mass (k)
Dryden Rubber Div., Sheller Mfg. Co., Ill (m)
Dura Plastics of New York, Inc., NY (k)
Enflo Corp., NJ (l)
Fabricon Products Div., Eagle-Picher Co., Mich (l)
Falge Engineering Corp., Md (k)
Federal Tool Corp., Ill (k)
Fiber Glass Industries, Inc., NY (l)
Formica Corp., Sub. of American Cyanamid Co., Ohio (l)

Foster Grant Co., Mass (k)
Fry Plastics International, Calif (k)
Galigher Co., Utah (k)
Garlock Packing Co., NY (k,m)
General American Transportation Corp., Ill (k)
General American Transportation Corp., Plastics Div., Ill
(k)—Ad p 411
General Electric Co., Chemical & Metallurgical Div., Ill (m)
General Plastics Corp., Ind (k)
General Plastics Mfg. Co., Wash (k,m)
General Tire & Rubber Co., Ind (l)
Glastic Corp., Ohio (l)
H & R Industries, Pa (k)
Haveg Industries, Inc., Del
(l)—Ad pp 425-426
Hays Mfg. Co., Pa (l)
Heil Process Equipment Corp., Ohio (k,l,m)
Hewitt-Robins, Inc., Conn (m)
Hohwieler Rubber Co., Inc., Pa (m)
Klise Mfg. Co., Mich (k)
Lone Star Plastics Co., Inc., Tex (k)
Luminous Resins, Inc., Ill (k)
Lunn Laminates, Inc., NY (k,l)
Lus-Trus Corp., Mich (k)
Luzerne Rubber Co., NJ (k,l)
Madin Plastics Inc., NJ (k)
Marblette Corp., NY (l)
Mica Insulator Co., NY (l)
Micarta Div., Westinghouse Electric Corp., SC (k,l)
Midwest Plastic Products Co., Ill (k)
Minnesota Mining & Mfg. Co., Minn (l)
Nalge Co., Inc., NY (k)
National Vulcanized Fibre Co., Del (l)
Newth Rubber Co., RI (m)
Nopco Chemical Co., NJ (l)
O'Sullivan Rubber Corp., Va (k)
Panelyte Div., St. Regis Paper Co., NJ (k)
Plastic Products Corp., Ohio (k)
Pyro Plastics Corp., NJ (k)
Pyrosil, Inc., Ohio (l)
Quelcor, Inc., Pa (k)
Regal Plastic Co., Mo (k)
Reinhold Engineering & Plastics Co., Inc., Calif (l)
Rogers Corp., Conn (l,m)
St. Clair Rubber Co., Mich (m)
Schori Process Div., Ferro-Co Corp., NY (l)
Sealview Plastics, Inc., Pa (k)
Seamless Rubber Co., Conn (m)
Shamban, W.S. & Co., Ind (k)
Shoe Form Co., Inc., DeWitt Plastics Div., NY (k)
Sierra Electric Corp., Calif (k,l)
Silicocks Miller Co., NJ (k)
Snyder Mfg. Co., Inc., Ohio (k)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (k)
Strick Plastic Co., Pa (k,m)
Superior Plastics, Inc., Ill (k)
Swedlow, Inc., Calif (k,l)
Synthane Corp., Pa (l)
Taunton Div., Haveg Industries, Inc., Mass (m)
Texstar Plastics Div., Texstar Corp., Tex (k,l)
Toyad Corp., Pa (k)
Tuff Clad, Inc., Ohio (k)
U.S. Gasket Plastics Div., Garlock Packing Co., NJ (k,l)
U.S. Rubber Co., Mechanical Goods Div., Ind (k)
Universal Unlimited, Inc., NY (k)
Valley-National Corp., Conn (k)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (m)
Western Felt Works, Ill (l,m)
Westlake Plastics Co., Pa (k)
Williams-Bowman Rubber Co., Ill
(l,m)—Ad p 276
Woodall Industries, Inc., Mich (k)

Moldings, Slush

(plastics and rubber)

American Agile Corp., Ohio (k)
Automotive Rubber Co., Inc., Mich (m)
Boonton Molding Co., NJ (m)
Borden Co., Borden Chemical Div., NY (k)
Chicago-Allis Mfg. Corp., Ill (m)
Dennis Chemical Co., Mo (k)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (k)
Dumont Corp., Calif (l)
Hungerford Plastics Corp., NJ (k,m)
Madin Plastics Inc., NJ (k)
Munray Products Div., Fanner Mfg. Co., Ohio (k,l,m)
Pyrosil, Inc., Ohio (l)
Quelcor, Inc., Pa (k)
Sheller Mfg. Corp., Mich (k,l,m)
Steere Enterprises, Inc., Ohio (m)
Tuff Clad, Inc., Ohio (k)
U.S. Stoneware Co., Ohio (k)
Western Textile Products Co., Mo (k,m)

Moldings, Transfer

Accurate Molding Corp., NY (l)
Acushnet Process Co., Mass
(m)—Ad p 448
Admiral Corp., Molded Products Div., Ill (l)
Aerojet-General Corp., Structural Materials Div., Calif (l)
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (l)
Alcylite Plastics & Chemical Corp., Calif (l)
American Hard Rubber Co., Div. of Amerace Corp., NJ (k,l)
American Insulator Corp., Pa (l)
American Plastics Corp., NY (l)
American Sinterings Div., Engineered Plastics, Inc., Conn (l)
Auburn Mfg. Co., Conn
(k)—Ad p 450
Auburn Plastics, Inc., NY (l)
Automotive Rubber Co., Inc., Mich (m)
Bangor Plastics, Inc., Mich (l)
Belko Corp., Md (m)
Biwax Corp., Ill (l)
Bond International, Inc., Mich (m)
Booker & Wallestad, Inc., Minn (l)
Boonton Molding Co., NJ (k)
Bridgeport Moulded Products, Inc., Conn (l)
Canfield, H.O. Co., Va (l,m)
Capac Mfg. Corp., Mich (l,m)
Chicago Molded Products Corp., Ill (l)
Chicago Molded Products Corp., Custom Molding Div., Ill (l)
Chicago Rawhide Mfg. Co., Ill (k,m)
Chicago-Allis Mfg. Corp., Ill (m)
Cincinnati Industries Inc., Ohio (k,l)
Colonial Rubber Co., Div. of U.S. Stoneware Co., Ohio
(k,m)—Ad p 441
Colt's Plastics Co., Inc., Conn (l)
Consolidated Molded Products Corp., Pa (l)
Continental Rubber Works, Pa (m)
Dayton Rogers Mfg. Co., Minn (k,l)
Dayton Rubber Co., Ohio (m)
Dayton Rubber Co., Molded Products Div., Mich (l)
Delta Plastics Co., NJ (l)
Dimco-Gray Co., Ohio (l)
Disogrin Industries, Inc., NY (m)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (k)
Electronic Production & Development, Inc., Chemical Div., Calif (l)
Faultless Rubber Co., Ohio (m)
Fiberglass Ohio Inc., Ohio (l)
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass (m)
Formica Corp., Sub. of American Cyanamid Co., Ohio (k)
Galigher Co., Utah (m)
Garfield Mfg. Co., NJ (l)
Garlock Packing Co., NY (k,m)
General American Transportation Corp., Ill (k,l)
General American Transportation Corp., Plastics Div., Ill
(l)—Ad p 411
General Electric Co., Chemical & Metallurgical Div., Ill (l)
General Electric Co., Plastics Dept., Ill (l,m)
General Industries Co., Molded Plastic Div., Ohio (l)
Goodrich, B.F. Industrial Products Co., Ohio (k)
Grimes Mfg. Co., Plastic Research Products Div., Ohio (l)
Haveg Industries, Inc., Del
(l)—Ad pp 425-426
Hawkeye Rubber Mfg. Co., Iowa (m)
Hohwieler Rubber Co., Inc., Pa (m)
Houghton, E.F. & Co., Pa (m)
Industrial Molded Products Co., Inc., Ill (l)
Insulation Products Co., Pa (l)
Johnson Rubber Co., Ohio (m)
Judsen Rubber Works, Inc., Ill (m)
Kerrco, Neb (k,l)
Kurz Kasch, Inc., Ohio (l)
Lee Rubber & Tire Corp., Pa (m)
Lone Star Plastics Co., Inc., Tex (l)
Loranger Mfg. Corp., Pa (l)
Luzerne Rubber Co., NJ (k,l)
Mack Molding Co., NJ (l)
Marion Div., General Tire & Rubber Co., Ind (l)
Martin Rubber Co., Inc., NJ (m)
Mesa Plastics Co., Calif (l)
Mid-States Rubber Products, Inc., Ind (m)
Midwest Molding & Mfg. Co., Ill (l)
Minnesota Rubber Co., Minn (l,m)
Moxness Products, Inc., Wis
(l,m)—Ad p 460
National Lock Co., Ill (l)
Paeco Rubber Co., Inc., Ohio (k,l,m)
Panelyte Div., St. Regis Paper Co., NJ (l)
Parker Appliance Co., Rubber Products Div., Ohio (m)
Parker Seal Co., Div. of Parker-Hannifin Corp., Calif (m)
Perry Plastics, Inc., Pa (l)
Plastic Research Products Co., Div. of Grimes Mfg. Co., Ohio (l)
Plasticrafters, Inc., Ill (l)
Porter, William Co., Calif (l)
Precision Rubber Products Corp., Ohio (m)
Raybestos-Manhattan, Inc., NJ (m)
Reinhold Engineering & Plastics Co., Inc., Calif (l)
Resistoflex Corp., NJ (k)
Richardson Co., NY (l)
Rogers, V.F. Plastic Molding, Colo (l,m)
Romar Plastics, Inc., Ill (l)
Rostone Corp., Ind (l)
Roth Rubber Co., Ill (m)
St. Clair Rubber Co., Mich (m)
Seamless Rubber Co., Conn (m)
Shaw Insulator Co., NJ (l)
Sheller Mfg. Corp., Mich (k,l,m)
Sierra Electric Corp., Calif (l)
Sierra Engineering Co., Calif (m)
Southern Plastics Co., SC (l)
Standard Plastics Co., Mass (l)
Stockwell Rubber Co., Inc., Pa (m)
Stokes Molded Products, Div. of Electric Storage Battery Co., NJ (l)
Stowe-Woodward, Inc., Mass (m)
Sun Rubber Co., Ohio (m)
Sylvania Electric Products, Inc., Parts Div., Pa (l)
Taunton Div., Haveg Industries, Inc., Mass (k,l,m)
Tingley Rubber Corp., NJ (m)
Toledo Industrial Rubber Co., Ohio (l,m)
Trostel, Albert Packing, Ltd., Wis (m)
U.S. Rubber Co., Mechanical Goods Div., Ind (l)
Vulcanized Rubber & Plastics Co., Pa (m)
Waldman, Joseph & Sons, Epoxy Products Div., NJ (l)
Waterbury Cos. Inc., Conn (l)
Western Felt Works, Ill (l,m)
Whitso, Inc., Ill (l)
Williams-Bowman Rubber Co., Ill
(l,m)—Ad p 276
Wyatt Industries Inc., Plastic & Rubber Div., Tex (l,m)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Molybdenum and Its Alloys

Alloy Metal Products, Inc., Iowa (o,w)
Alpha Metals, Inc., NJ (cc,dd)
Amalgamated Steel Corp., Ohio (o,bb)
American Metal Climax, Inc., NY (o,q,z,aa,bb,cc,dd)
American Nickel Alloy Mfg. Corp., NY (w,aa)
American Silver Co., NY (v,dd,ee,ff)
Associated Engineering & Mfg. Corp., NJ (n,o,aa,bb,cc,dd,ee,ff)
Belmont Smelting & Refining Works, Inc., NY (o,w,aa)
Bridgeport Brass Co., Conn (ee)
Cleveland Tungsten Inc., Ohio (aa,bb,ee)

Climax Molybdenum Div., American Metal Climax, Inc., NY (o,q,w,z,bb, cc,dd)
Crucible Steel Co. of America, Titanium & Vacuum Metals Product Div., Pa (o,q,w,z,cc,dd)
Damascus Tube Co., Pa (ee)
Electronic Parts Mfg. Co., Inc., NJ (z,bb,cc,ee,ff)
Elmet Div., North American Phillips Co., Inc., Me (o,w,z,aa,bb,cc,dd,ff)
Fansteel Metallurgical Corp., Ill
(n,o,q,v,w,z,aa,bb,cc,dd,ee,ff) — Ad p 174
Firth Sterling, Inc., Pa (q)
General Electric Co., Lamp Metals & Components Dept., Ohio (o,q,w,aa,bb, cc,dd,ff)
Hamilton Watch Co, Precision Metals Div., Pa (v,dd,ff)
Hardy, Charles, Inc., NY (aa)
Harvey Aluminum, Calif (o,bb)
Hayden Wire Works, Inc., Mass (aa,ff)
Johnston & Funk Titanium Corp., Ohio (bb,ff)
Kassel Export Co., Inc., NJ (v,bb,dd, ee,ff)
Mallory, P.R. & Co., Inc., Ind (aa, bb)
Mallory-Schwarzkopf Metals, Inc., NY (o,v,w,z,bb,cc,dd,ee,ff)
Metal & Thermit Corp., NJ (w)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Metallizing Engineering Co., Inc., NY (ff)
Molybdenum Corp. of America, Pa (o,w,z,aa,bb,cc,dd)
National-Standard Co., Mich
(ff)—Ad p 421
North American Phillips Co., Inc., Me (aa)
Nuclear Metals, Inc., Mass (w,ee)
Oregon Metallurgical Corp., Ore (w)
Reduction & Refining Co., NJ (q,w,aa, bb,ff)
Rodney Metals, Inc., Mass (v,dd)
Shieldalloy Corp., NJ (aa)
Stauffer Chemical Co., NY
(q)—Ad p 163
Stauffer-Temescal Co., Calif (q,w)
Sylvania Electric Products, Inc., Chemical & Metallurgical Div., Pa
(n,w,aa,bb,ff)—Ad p 153
Tube Distributors Co., Inc., NY (ee)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
Universal-Cyclops Steel Corp., Pa (o,q, z,cc)
Utica General Jobbing Foundry, Inc., NY (aa)
Wah Chang Corp., NY
(n,aa,bb,ff)—Ad p 164
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb, cc,dd,ee)

Monel
(see Nickel)

Neoprene
(see Chloroprene Rubber)

Nickel and Its Alloys
Advance Stamping Co., Miuh (dd)
Allied Research Products, Inc., Md (n)
Alloy Metal Powders, Inc., NY (aa)
Alloy Metal Products, Inc., Iowa (o, w)
Amalgamated Steel Corp., Ohio (o,bb)
American Metal Climax, Inc., NY (aa)
American Nickel Alloy Mfg. Corp.,NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
American Silver Co., NY (v,dd,ee,ff)
American Smelting & Refining Co., NY (n,w)
Arcos Corp., Pa (ff)
Auld, D.L. Co., Ohio (n)
Austenal Co., Div. of Howe Sound Co., NY (w)
Bart Mfg. Corp., NJ (aa)
Belmont Smelting & Refining Works, Inc., NY (n,o,w,aa)
Biddle Screw Products Co., Ind (o, bb,ee)
Bishop, J. & Co. Platinum Works, Pa (ee,ff)
Bridgeport Brass Co., Conn (bb,cc,dd, ee,ff)
Brinkerhoff Brass & Bronze Works, Inc., NY (cc,dd)
Brush Beryllium Co., Ohio (w)
Cannon-Muskegon Corp., Mich (o,v,w, cc,dd,ff)
Carpenter Steel Co., Webb Wire Div., NJ (ff)
Central Fabricators, Inc., Ohio (z, bb,cc,ee)
Chase Brass & Copper Co., Inc., Sub. of Kennecott Copper Corp., Conn (o,bb,cc,ee)
Chicago Steel Service Co., Ill (o,q,z, bb,cc,dd,ee,ff)
Chromium Corp. of America, NY (v)
Craft Metal Spinning Co., Ill (cc)
Crane Co., Metals Div., Pa (aa)
Crucible Steel Co. of America, Titanium and Vacuum Metal Products Div., Pa (o,q,v,z,bb,cc,dd,ee,ff)
Damascus Tube Co., Pa (ee)
Designers Metal Corp., Ill (cc)
Dixon Sintaloy, Inc., Conn (o)
Dormont Mfg. Co., Pa (ee)
Driver, Wilbur B. Co., NJ
(v,bb,dd,ff)—Ad p 185
Driver-Harris Co., NJ (v,bb,dd,ff)
Electronic Parts Mfg. Co., Inc., NJ (bb,dd,ee,ff)
Elgin National Watch Co., Abrasives Div., Ill (o,bb,dd,ff)
Erskine Precision Wire Corp., Pa (ff)
Federated Metals Div., American Smelting & Refining Co., NY (n)
Foote Mineral Co., Pa (w,aa)
Fox Products Co., Pa (n)
Fromson Orban Co., Inc., NY (ee)
General Electric Co., Metallurgical Products Dept., Mich (q,w,aa,bb,cc, dd)
General Plate Div., Metals & Controls Corp., Mass (v,cc,dd)
Gibson Electric Co., Pa.
(bb,dd,ff)—Ad p 466
Grand Rapids Brass Co., Mich (z)
Hamilton Watch Co., Precision Metals Div., Pa (v,w,bb,dd)
Hardy, Charles, Inc., NY (aa)
Harshaw Chemical Co., Ohio (n)
Hayden Wire Works, Inc., Mass (aa,ff)
Haynes Stellite Co., Div. of Union Carbide Corp., Ind (o,q,v,w,z,aa,bb, cc,dd,ee,ff)
Horton-Angell Co., Mass (n,o,bb,cc, ee,ff)
Hoskins Mfg. Co., Mich
(bb,dd,ff)—Ad p 177
International Nickel Co., Inc., NY (n,z,bb,cc,dd,ee,ff)
Jelliff, C.O. Mfg. Corp., Conn (ff)
K. & L. Plating Co., Pa (z)
Kanthal Corp., Conn (bb,dd,ff)
Kelse;-Hayes Co., Mich (o,q,z,cc)
Kelsey-Hayes Co., Metals Div., NY (o,q,v,w,z,bb,cc,dd,ff)
Kinkead Industries, Inc., Ill (cc,dd)
Lakeland Industries, Minn (z)
Lavin, R. & Sons, Inc., Ill (w)
Leach & Garner Co., Industrial Div., Mass (v,cc,dd,ee,ff)
McGean Chemical Co., Ohio (n,o,bb,dd)
Metal Forming Corp., Div. of Vanadium-Alloys Co., Ind (ee)
Metal Goods Corp., Mo (o,z,bb,cc,dd, ee,ff)
Metal Hybrides, Inc., Mass (aa)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Metallizing Engineering Co., Inc., NY (ff)
Metals Disintegrating Co., Inc., NJ (aa)
Michigan Seamless Tube Co., Mich (ee)
Modern Plating Corp., Ill (n)
National Lead Co., NY (q,w)
National-Standard Co., Mich
(ff)—Ad p 421
National-U.S. Radiator Corp., Plastic Metals Div., NY (aa)
Nesor Alloy Products Co., NJ (ff)
New England Brass Co., Mass (cc,dd)
New Jersey Metals Co., NJ (n,q,w)
New Jersey Zinc Co., NY
(aa)—Ad pp 452-453
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb,ee)
Norwalk Powdered Metals, Inc., Conn (aa)
Nuclear Metals, Inc., Mass (w,bb,dd, ee)
Precision Tube Co., Inc., Pa (ee)
Pyron Corp., NY (aa)
Rathbone Corp., Mass (o,bb)
Republic Steel Corp., Steel & Tubes Div., Ohio (ee)
Rigidized Metals Corp., NY (cc,dd)
Riverside-Alloy Metal Div., H.K. Porter Co., Inc., NJ
(bb,dd,ff)—Ad p 160
Rolock, Inc., Conn (ff)
Sandusky Foundry & Machine Co., Ohio (ee)
Sel-Rex Corp., NJ
(n,aa)—Ad p 356
Seymour Mfg. Co., Conn
(n)—Ad p 178
Shenango Furnace Co., Centrifugally Cast Products Div., Ohio (ee)
Sherwatt Equipment & Mfg. Co., Inc., NY (ff)
Shieldalloy Corp., NJ (aa)
Sierra Metals Corp., Sub. of American-Marietta Co., Ill (w)
Somers Brass Co., Inc., Conn
(v,dd)—Ad p 162
Standard Metals Corp., Mass (ee)
Stauffer-Temescal Co., Calif (o,q,w,z, bb,cc,dd,ee,ff)
Stevens, Frederic B., Inc., Mich (n)
Superior Steel Corp., Pa (dd)
Superior Tube Co., Pa (ee)
Sylvania Electric Products, Inc., Parts Div., Pa (ff)
Techalloy Co., Inc., Pa (o,v,bb,cc,dd, ff)
Trent Tube Co., Sub. of Crucible Steel Co. of America, Pa (ee)
Tube Distributors Co., Inc., NY (ee)
Tube Methods Inc., Pa (ee)
Tube Reducing Corp., NJ (ee)
Udylite Corp., Mich (n)
Ullmann, Inc., Wis (o,ee)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
United Wire & Supply Corp., RI (ff)
Universal-Cyclops Steel Corp., Pa (o, q,z,bb,cc,dd,ff)
Utica General Jobbing Foundry, Inc., NY (aa)
Utility Mfg. Co., Mass (bb)
Vanadium-Alloys Steel Co., Pa (aa)
Walmet Alloys Co., Mich
(w)—Ad p 82
Wall Colmonoy Corp., Stainless Process Div., Mich (w,aa,bb)
Wall Tube & Metal Products Co., Tenn (ee)
Wallingford Steel Co., Conn (dd,ee)
Waterbury Rolling Mills, Inc., Conn (dd)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb,cc, dd,ee)
Whitehead Metal Products Co., Inc., NY (o,q,z,bb,cc,dd,ee,ff)
Wilson, H.A. Co., Div. of Engelhard Industries, Inc., NJ (bb,dd)
Wisconsin Centrifugal Foundry, Inc., Wis (ee)
Youngstown Welding & Engineering Co., Ohio (ee)

Nickel Silver
(see Copper)

Nitrides
(see Refractories)

Nitrile Rubber
(see Acrylonitrile-Butadiene Rubber)

Nodular Iron
(see Iron)

Nylon
(see Polyamides)

Organic Coatings
(formulations — lacquers, enamels, etc; see also Precoated Metals)
Abalon Precision Mfg. Corp., NY
Acheson Colloids Co., Mich
Acme Plating Co., Ohio
Acme Stamping & Wire Forming Co., Pa
Alcylite Plastics & Chemical Corp., Calif
AllianceWall Div., AllianceWare, Inc., Ohio
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY
Allied Research Products, Inc., Md
—Ad p 358
Alpha-Molykote Corp., Conn
Aluminum Co. of America, Pa
Amercoat Corp., Calif
American Cynamid Co., Plastics & Resins Div., NY
American Solder & Flux Co., Pa
American-Marietta Co., Ill
Armitage, J.L. & Co., NJ
Ashtabula Mfg. Co., Ohio
Atlas Mineral Products Co., Pa
Auld, D.L. Co., Ohio
Automotive Rubber Co., Inc., Mich
Avondale Co., Ill
B.B. Chemical Co., Bostik Dept., Mass.
Babbitt Chemical Co., Inc., Mass
Barrett Varnish Co., Ill
Bee Chemical Co., Ill
Berry Bros., Mich
Biggs, Carl H. Co., Inc., Calif
Bisonite Co., Inc., NY
Boatwright Paint & Varnish Works, Inc., Ga
Borden Chemical Div., Borden Co., NY
Bradley Paint Co., Pa
Bradley & Vrooman Co., Ill
Brandt, Charles T., Inc., Md
Burwood Products Co., Mich
Capitol Chemical Co., Ill
Carboline Co., Mo
Ceilcote Co., Ohio
Cellusuede Products, Inc., Ill
(flock)—Ad p 363
Chemical Coatings Corp., Conn
Chemical Coatings & Engineering Co., Inc., Pa
Chemical Development Corp., Mass
Chemical Process Co., Calif
Chemical Products Corp., RI
Clinton Co., Ill
Commercial Chemical Co., Ohio
Co-Polymer Chemicals Inc., Mich
Cordo Chemical Corp., Conn
Davis Products Corp., NY
Day, James B. & Co., Ill
Dayton Rubber Co., Ohio
Debevoise Co., NY
Dennis Chemical Co., Mo
Designers Metal Corp., Ill
De Soto Paint & Varnish Co., Tex
Dirilyte Co. of America, Inc., Ind
Doehler-Jarvis Div., National Lead Co., Ohio
Dolfin Corp., NJ

Douglas & Sturgess, Calif
du Pont de Nemours, E. I. & Co., Inc., Del
Duralac Chemical Corp., NJ
Dyna-Therm Chemical Corp., Calif
Earl Paint Corp., NY
Egan & Hausman Co., Inc., NY
Egyptian Lacquer Mfg. Co., NJ
Electro Chemical Engineering & Mfg Co., Pa
Electrofilm, Inc., Calif
Electronic Production & Development, Inc., Chemical Div., Calif
Enamelstrip Corp., Sub. of National Steel Corp., Pa
Enthone, Inc., Conn
—Ad p 350
Everlite Corp., Wash
Fidelity Chemical Products Corp., NJ
Flexrock Co., Pa
Forbes Finishes Div., Pittsburgh Plate Glass Co., Ohio
Foss Mfg. Co., Id
Fox Co., Ohio
Furane Plastics Inc., Calif
Gates Engineering Co., Del
General Electric Co., Chemical Materials Dept., Mass
General Plastics Corp., NJ
General Plastics Mfg. Co., Wash
Globe Paint Works, Inc., Pa
Goodyear Tire & Rubber Co., Chemical Div., Ohio
Graphite Products Corp., Ohio
Grand Rapids Varnish Corp., Mich
Grems Mfg. Co., Ore
Hardman, H.V. Co., Inc., NJ
Haveg Industries, Inc., Del
Hilo Varnish Corp., Industrial Finishes Div., Mass
Horn, A.C. Co., Inc., Div. of Sun Chemical Corp., NY
Hughson Chemical Co., Div. of Lord Mfg. Co., Pa
Hysol Corp., NY
Industrial Metal Protectives Inc., Ohio
Industrial Paint Div., Glidden Co., Ohio
Industrial Polychemical Service, Calif
Interchemical Corp., Finishes Div., NJ
Jamestown Finishes, NY
Jasper Lacquer Co., Inc., Ind
Jema-American, Inc., NJ
Jervis Corp., Mich
Johnson, S.C. & Son, Inc., Wis
Jones-Dabney Co., Div. of Devoe & Raynolds Co., Inc., Ky
Keystone Refining Co., Inc., Pa
Kish Industries, Inc., Mich
Knight, Maurice A., Ohio
Lacquer & Chemical Corp., NY
Lacquer Products, Inc., Ohio
Lakewood Metal Products, Inc., Conn
Landau, J. & Co., Inc., NJ
Lithcote Corp., Ill
Lowe Bros. Co., Ohio
Maas & Waldstein Co., NJ
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Magic Chemical Co., Mass
Magnesium Co. of America, Ind
Marblette Corp., NY
Masonite Corp., Ill
McDougall Butler Co., Inc., NY
McGee Chemical Co., Inc., Pa
Mearl Corp., NY
Merix Chemical Co., Ill
Metal & Thermit Corp., NJ
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Micarta Div., Westinghouse Electric Corp., SC
Michigan Chrome & Chemical Co., Mich
Midland Industrial Finishes Co., Ill
Minnesota Paints, Inc., Minn
Mirro Aluminum Co., Wis
Mobay Chemical Co., Pa
Mobile Paint Mfg. Co., Inc., Ala
Modern Plating Corp., Ill
Mono-Seal Products Div., Downer, Hunnewell, Inc., Mass
Monsanto Chemical Co., Organic Chemicals Div., Mo
Munray Products Div., Fanner Mfg. Co., Ohio
Narmco Industries, Inc., Narmco Materials Div., Calif
National Mfg. Corp., NY
Naugatuck Chemical Div., U.S. Rubber Co., Conn
Navan Products, Inc., Sub. of North American Aviation, Inc., Calif
New Jersey Zinc Co., NY
Nikolas, G.J. & Co., Inc., Ill
Nukem Products Corp., NY
Octagon Process, Inc., NY
Owens-Illinois Glass Co., Closure & Plastics Div., Ohio
Paramount Paint & Lacquer Co., Calif
Parker Paint Mfg. Corp., Ind
Pecora, Inc., Pa
Penn Metal Co., Inc., W.Va
Perry-Austen Mfg. Co., NY
Peterson, D.J. Co., Wis
Philadelphia Enameling Works, Inc., Pa
Pierce, F.O. Co., NY
Pierce & Stevens Chemical Corp., NY
Pittsburgh Plate Glass Co., Pa
Pittsburgh Steel Co., Pa
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif
Plume & Atwood Mfg. Co., Conn
Polymer Corp., Pa
Polymer Industries Inc., Conn
Powell Pressed Steel Co., Ohio
Pratt & Lambert, Inc., NY
Promat Div., Poor & Co., Ill
Queen Products Co., Inc., Ky
Quelcor, Inc., Pa
Radiant Color Co., Calif
Radiation Applications, Inc., NY
Raffi and Swanson, Inc., Mass
Randolph Products Co., NJ
Raybestos-Manhattan, Inc., NJ
Raybestos-Manhattan, Inc., Adhesives Div., Conn
Reynolds Aluminum Supply Co., Ga
Reynolds Chemical Products Co., Mich
Riegel Paper Corp., NY
Rinshed-Mason Co., Mich
Rodney Metals, Inc., Mass
Rosco Laboratories, NY
Rubber Corp. of America, NY
Rust-Oleum Corp., Ill
Sanford Process Co., Inc., Calif
Saran Protective Coatings Co., Mich
Sauereisen Cements Co., Pa
Schori Process Div., Ferro-co Corp., NY
Schwartz Chemical Co., Inc., NY
Seal-Peel, Inc., Mich
Sealube Co., Mass
Seaporcel Metals, Inc., NY
Sherwin-Williams Co., Ohio
Sierra Engineering Co., Calif
Simonsen Metal Products Co., Ill
Spraylat Corp, NY
Stanley Chemical Co., Conn
Steel Protection & Chemical Co., Ind
Steelcote Mfg. Co., Mo
Subox, Inc., NJ
Sun Steel Co., Ill
Superior Plastics, Inc., Ill
Textileather Div., General Tire & Rubber Co., Ohio
Thompson and Co., Pa
Tousey Varnish Co., Ill
Tubular Rivet & Stud Co., Mass
Tuff Clad, Inc., Ohio
Union Chemical Corp., NJ
Union Paste Co., Mass
United Shoe Machinery Corp., Mass
U.S. Stoneware Co., Ohio
Waterbury Cos., Inc., Conn
Watson-Standard Co., Pa
Wesbar Stamping Corp., Wis
Western Coating Co., Mich
Westinghouse Electric Corp., Pa
Worth Co., Wis
Zeller Corp., Ohio
Zolatone Process, Inc., Calif

Organic Coatings

(coaters)

Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich
Aldan Rubber Co., Pa
Alloy Products Corp., Wis
Aluminum Co. of America, Pa
Aluminum Specialty Co., Wis
American Emblem Co., Inc., NY
American Hard Rubber Co., Div. of Amerace Corp., NJ
Arbonite Corp., Pa
Ashtabula Mfg. Co., Ohio
Atlas Mineral Products Co., Pa
Auld, D.L. Co., Ohio
Automotive Rubber Co., Inc., Mich
Avondale Co., Ill
Bee Chemical Co., Ill
Biggs, Carl H. Co., Inc., Calif
Bishopric Products Co., Ohio
Bisonite Co., Inc., NY
Boatwright Paint & Varnish Works, Inc., Ga
Bradley Paint Co., Pa
Brandt, Charles T., Inc., Md
Caspers Tin Plate Co., Ill
Chemical Development Corp., Mass
Coated Coil Corp., NY
Cohan Epner Co., Inc., NY
Colonial Alloys Co., Pa
Cordo Chemical Corp., Conn
Croname, Inc., Ill
Day, James B. & Co., Ill
Debevoise Co., NY
Dirilyte Co. of America, Inc., Ind
Dolin Metal Products, Inc., NY
Dollin Corp., NJ
Douglas & Sturgess, Calif
Dyna-Therm Chemical Corp., Calif
Earl Paint Corp., NY
Electro Chemical Engineering & Mfg. Co., Pa
Electro Technical Div., Sun Chemical Corp., NJ
Electrofilm, Inc., Calif
Emerson & Cuming, Inc., Mass
Enamelstrip Corp., Sub. of National Steel Corp., Pa
Everlite Corp., Wash
Eyelet Specialty Div., International Silver Co., Conn
Falstrom Co., NJ
Farwell Metal Fabricating, Minn
Fletcher Enamel Co., W.Va
Forbes Finishes Div., Pittsburgh Plate Glass Co., Ohio
Foss Mfg. Co., Id
Fuller, H.B. Co., Minn
Gates Engineering Co., Del
General Plastics Corp., NJ
Globe Paint Works, Inc., Pa
Gomar Mfg. Co., Inc., NJ
Goodrich, B.F. Industrial Products Co., Ohio
Grand Rapids Brass Co., Mich
Grand Rapids Varnish Corp., Mich
H & R Industries, Pa
Hartglas Co., Ohio
Haveg Industries, Inc., Del
Hayden Wire Works, Inc., Mass
Hilo Varnish Corp., Industrial Finishes Div., Mass
Hughson Chemical Co., Div. of Lord Mfg. Co., Pa
Industrial Metal Protectives, Inc., Ohio
Industrial Paint Div., Glidden Co., Ohio
Jamison Plastic Corp., NY
Jervis Corp., Mich
Johnson, S.C & Son, Inc., Wis
Kelley Mfg. Co., Tex
Kickhaefer Mfg. Co., Wis
King, Alfred B., Co., Conn
Lakewood Metal Products, Inc., Conn
Lacquer & Chemical Corp., NY
Lithcote Corp., Ill
Lowe Bros. Co., Ohio
Ludlow Plastics, Mass
Luzerne Rubber Co., NJ
Maas & Waldstein Co., NJ
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Magic Chemical Co., Mass
Merix Chemical Co., Ill
Metal-Cladding, Inc., NY
Metalweld, Inc., Protective Coating Div., Pa
Met-L-Wood Corp., Ill
Michigan Chrome & Chemical Co., Mich
Miller-Stephenson Chemical Co., Inc., Conn
Minnesota Mining & Mfg. Co., Adhesives, Coatings & Sealers Div., Mich
Modern Plating Corp., Ill
Morton Mfg. Co., Ill
Munray Products Div., Fanner Mfg. Co., Ohio
Montague Machine Co., Mass
Narmco Industries, Inc., Narmco Materials Div., Calif
National Lock Co., Ill
National Metal Products Co., Pa
Nikolas, G.J. & Co., Inc., Ill
Norgren-Stemac, Inc., Colo
Pecora, Inc., Pa
Peterson, D.J. Co., Wis
Polacoat, Inc., Ohio
Polymer Corp., Pa
Quelcor, Inc., Pa
Radiant Color Co., Calif
Radiation Applications, Inc., NY
Raffi and Swanson, Inc., Mass
Respro Div., General Tire & Rubber Co., RI

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Riegel Paper Corp., NY
Rust-Oleum Corp., Ill
Rustproofing & Metal Finishing Corp., Mass
Schori Process Div., Ferro-co Corp., NY
Schwartz Chemical Co., Inc., NY
Smith-Victor Corp., Ind
Smoot-Holman Co., Calif
Steelcote Mfg. Co., Mo
Stirrup Metal Products Corp., NJ
Sun Steel Co., Ill
Superior Plastics, Inc., Ill
Textileather Div., General Tire & Rubber Co., Ohio
Toyad Corp., Pa
Tuff Clad, Inc., Ohio
Union Chemical Corp., NJ
U.S. Stoneware Co., Ohio
United-Carr Fastener Corp., Mass
Wayne Chemical Products Co., Mich
Woodstock Div., Electric Auto-Lite Co., Ill
Worth Co., Wis
Zolatone Process, Inc., Calif
Zophar Mills, Inc., NY

Organic Coatings —Claddings

(see also Laminates, Metal-Organic)

American Hard Rubber Co., Div. of Amerace Corp., NJ
Arvin Industries, Inc., Ind
Automotive Rubber Co., Inc., Mich
Chemical Products Corp., RI
Clad-Rex Corp., Ill
Electro Chemical Engineering & Mfg. Co., Pa
Lithcote Corp., Ill
Metal-Cladding, Inc., NY
Nukem Products Corp., NY
O'Sullivan Rubber Corp., Plastics Div., Va
Penn Metal Co., Inc., W.Va
Polymer Corp., Pa
Quelcor, Inc., Pa
Radiation Applications, Inc., NY
Seiberling Rubber Co., Plastics Div., Ohio
Sun Steel Co., Ill
Tuff Clad, Inc., Ohio
Watson-Standard Co., Pa

Organic Coatings —Prepainted Metals

Abalon Precision Mfg. Corp., NY
Aluminum Co. of America, Pa
Bridgeport Brass Co., Conn
Caspers Tin Plate Co., Ill
Clad-Rex Corp., Ill
Coated Coil Corp., NY
Cooley, W.J. & Co., Tenn
Dow Chemical Co., Mich
Enamelstrip Corp., Sub. of National Steel Corp., Pa
Fairmont Aluminum Co., W.Va
Falstrom Co., NJ
Fryling Mfg. Co., Pa
Hoofer Mfg. Co., Ill
Kaiser Aluminum & Chemical Sales Inc., Ill
Kees, F.D. Mfg. Co., Neb
Kinkead Industries, Inc., Ill
Lundquist Tool & Mfg. Co., Inc., Mass
Mahon, R.C. Co., Mich
National Metal Products Co., Pa
Penn Metal Co., Inc., W.Va
Philadelphia Steel & Wire Corp., Pa
Pittsburgh Steel Co., Pa
Republic Steel Corp., Ohio
Reynolds Aluminum Supply Co., Ga
Reynolds Metals Co., Va
Rigidized Metals Corp., NY
Rodney Metals, Inc., Mass
Roll Coater, Inc., Ind
Security Sash & Screen Co., Mich
Sharon Steel Corp., Pa
Sillcocks Miller Co., NJ
Stainless and Strip Div., Jones & Laughlin Steel Corp., Ohio
Sun Steel Co., Ill
Thomas Strip Div., Pittsburgh Steel Co., Pa

Organic Coatings, Strippable

Adhesive Products Corp., NY
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich
Amercoat Corp., Calif
American Latex Products Corp., Calif
Angier Adhesives Div., Interchemical Corp., Mass
Atlas Mineral Products Co., Pa
Avondale Co., Ill
Babbitt Chemical Co., Inc., Mass
Bee Chemical Co., Ill
Belding Corticelli Industries, NY
Better Finishes & Coatings, Inc., NJ
Bischoff Chemical Corp., NY
Bisonite Co., Inc., NY
Blaco Mfg. Co., Ohio
Borden Chemical Div., Borden Co., NY
Bradley & Vrooman Co., Ill
Carboline Co., Mo
Chemical Coatings & Engineering Co., Inc., Pa
Chemical Development Corp., Mass
Chemical Products Corp., RI
Daubert Chemical Co., Ill
Dennis Chemical Co., Mo
De Soto Paint & Varnish Co., Tex
Dip Seal Plastics, Inc., Ill
Diversey Corp., Metal Industries Div., Ill
Dow Chemical Co., Plastics Div., Mich
du Pont de Nemours, E. I. & Co., Inc., Del
Earl Paint Corp., NY
Fidelity Chemical Products Corp., NJ
Fine Organics, Inc., NY
Frost Paint & Oil Corp., Minn
George, P.D. Co., Mo
Globe Imperial Corp., Plastic-Seal Div., Ill
Houghton, E.F. & Co., Pa
Hughes Glue Co., Mich
Hughson Chemical Co., Div. of Lord Mfg. Co., Pa
Industrial Paint Div., Glidden Co., Ohio
Interchemical Corp., Finishes Div., NJ
Jamestown Finishes, NY
Johnson, S.C & Son, Inc., Wis
Kinkead Industries, Inc. Ill
Koster-Keunen Mfg. Co. Inc. NY
Lacquer & Chemical Corp., NY
Lacquer Products, Inc., Ohio
Landau, J. & Co., Inc., NJ
Maas & Waldstein Co., NJ
Magic Chemical Co., Mass
Metal & Thermit Corp., NJ
Micarta Div., Westinghouse Electric Corp., SC
Michelman Chemicals, Inc., Ohio
Midland Adhesive & Chemical Corp., Mich
Minnesota Mining & Mfg. Co., Adhesives, Coatings & Sealers Div., Mich
Minnesota Paints, Inc., Minn
Modern Plating Corp., Ill
Morningstar-Paisley, Inc., NY
Munray Products Div., Fanner Mfg. Co., Ohio
Nikolas, G.J. & Co., Inc., Ill
Nukem Products Corp., NY
Octagon Process, Inc., NY
Parker Paint Mfg. Corp., Ind
Pecora, Inc., Pa
Pennsalt Chemicals Corp., Pa
Pierce & Stevens Chemical Corp., NY
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif
Plume & Atwood Mfg. Co., Conn
Poly Resins, Calif
Polyken Sales Div., Kendall Co., Ill
Polymer Chemical Co., Ohio
Polymer Industries, Inc., Conn
Protective Treatments, Inc., Ohio
Puritan Co., Inc., NY
Pyramid Plastics, Inc., Ill
Quelcor, Inc., Pa
Radiation Applications, Inc., NY
Reynolds Chemical Products Co., Mich
Schwartz Chemical Co., Inc., NY
Seal-Peel, Inc., Mich
Serwell Products Co., Ohio
Sierra Engineering Co., Calif
Spraylat Corp., NY
Sun Steel Co., Ill
Thompson and Co., Pa
Turco Products, Inc., Calif
Union Chemical Corp., NJ
Union Paste Co., Mass
U.S. Rubber Co., NY
U.S. Stoneware Co., Ohio
Valvoline Oil Co., Div. of Ashland Oil & Refining Co., Pa
Watson-Standard Co., Pa
Wayne Chemical Products Co., Mich
Western Coating Co., Mich
Whitfield Chemical Co., Mich
Xylos Rubber Co., Ohio
Zophar Mills, Inc., NY

Oxide Coatings

(see Conversion Coatings)

Oxides

(see Ceramics; Refractories)

Paints

(see Organic Coatings)

Papers

(cellulose, inorganic, synthetic; for industrial use)

Allied Chemical Corp., Plastics & Coal Chemicals Div., NY
Auburn Mfg. Co., Conn
Avery Label Co., Decorative Products Div., Ohio
Consolidated Water Power & Paper Co., Wis
Dexter, C.H. & Sons, Inc., Conn
Filpaco Industries, Inc., Ill
Fox Edge Co., Inc., Mass
General Gasket, Inc., Conn
Georgia-Pacific Corp., Ore
Gomar Mfg. Co., Inc., NJ
Hollingsworth & Vose Co., Mass
Insulation Mfrs. Corp., Ill
Johns-Manville Corp., NY
Knowlton Bros., Inc., NY
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Mica Fabricating Co., NJ
Mosinee Paper Mills Co., Wis
National Gasket & Washer Mfg. Co., Inc., NY
Nicolet Industries, Inc., NY
Owens-Illinois Glass Co., Paper Products Div., Ohio
Panelyte Div., St. Regis Paper Co., NJ
Plymouth Cordage Co., Mass
Precision Paper Tube Co., Ill
Raybestos-Manhattan, Inc., NJ
Riegel Paper Corp., NY
Rogers Corp., Conn
Spaulding Fibre Co., Inc., NY
Spruce Pine Mica Co., Inc., NC
Standard Asbestos Mfg. Co., Ill
Standard Washer & Mat, Inc., Conn
Twitchell, E. W., Inc., Pa
Upson Co., NY
Vellumoid Co., Mass
Victor Mfg. & Gasket Co., Ill
West Virginia Pulp & Paper Co., NY
Wisconsin Gasket & Mfg. Co., Wis

Perforated Materials

Acme Precision Products, Inc., Ohio (a,b,g,h)
Aluminum Co. of America, Pa (a)
American Metal Products, Inc., Ohio (g)
American Nickel Alloy Mfg. Corp., NY (f)
Atlantic Steel Co., Ga (a,b,g)
BLC Porous Materials Co., Calif (a, b,e,f,g,j,k,l,m)
Biersach & Niedermeyer Co., Wis (a, b,c,f,g)
Blaco Mfg. Co., Ohio (b,g)
Bohn Aluminum & Brass Co., Mich (a)
Brockway Pressed Metals, Inc., Pa (b, c)
Burgess-Norton Mfg. Co., Ill (c)
California Perforated Screen Co., Calif (a,b,c,f,g,j)
Caspers Tin Plate Co., Ill (g)
Chase Brass & Copper Co., Sub. of Kennecott Copper Corp., Conn (b)
Clad-Rex Corp., Ill (a,g)
Clark Perforating Co., Mich (a,b,c,d, f,g,j,k,l,m)
Clendenin Bros., Inc., Md (a,b)
Colonial Alloys Co., Pa (a)
Colorado Fuel & Iron Corp., Colo (g)
Cross Engineering Co., Pa (a,g)
Diamond Mfg. Co., Pa (a,b,c,d,e,f,g,h, j)
Division Lead Co., Ill (d)
Duplex Mfg. Corp., Ark (g)
Edgcomb Steel & Aluminum Corp., NJ (a,g)
Ellwood City Iron & Wire Co., Pa (c)
Emerson-Sack-Warner Corp., Mass (a, b,f,g)
Erdle Perforating Co., Inc., NY (a, b,c,d,f,g,j,k,l)
Etched Products Corp., NY (a)
Falstrom Co., NJ (a,b,e,g)
Fletcher Enamel Co., W.Va (a,b,c,d,e, f)
Fox Products Co., Pa (c)
General Alloys Co., Mass (a,b,f)
Greene, G.G. Corp., Pa (g)
Grigoleit Co., Ill (a,g)
Harrington & King Perforating Co., Inc., Ill
(a,b,c,d,e,f,g,h,j,k,l,m)—Ad p 440
Hawkridge Bros. Co., Mass (a)
Hendrick Mfg. Co., Pa (a,b,c,d,e,f,g,h, j)
Houston Blow Pipe & Sheet Metal Works, Tex (a,b,g)
Ideal Can Co., Mass (g)
Industrial & Furnace Car Div., Irwin-Sensenich Corp., Pa (g)
Kees, F.D. Mfg. Co., Neb (g)
Levinson Steel Co., Pa (g)
Madin Plastics, Inc., NJ (k)
Manganese Steel Forge Co., Pa (g)
McCarter Iron Works, Inc., Pa (g)
McNally Pittsburgh Mfg. Co., Kan (a, g)
Melco Wire Products, Calif (a)
Morton Mfg. Co., Ill (a,g)
Mundt, Charles & Sons, NJ (a,b,c,d, e,f,g,h,j,k,l,m)
National Galvanizing Co., Pa (g)
National Lead Construction Co., Inc., NJ (d)
National-Standard Co., Mich
(a,b,f,g,h)—Ad p 421
Norwalk Powdered Metals, Inc., Conn (b)
Parker Metal Goods Co., Mass (g)
Perforating Industries, Inc., NJ
(k,l)—Ad p 450
Republic Steel Corp., Ohio (g)
Reynolds Metals Co., Va (a)
Rigidized Metals Corp., NY (a,b,f, g,h,j)
Rockwell Engineering Co., Ill (a,b,c,g)
Ryerson, Joseph T. & Son, Inc., Ill (a,g)

Servwell Products Co., Ohio (b,g)
Silicocks Miller Co., NJ (a,b)
Stainless Metals, Inc., NY (g)
Standard Stamping & Perforating Co., Ill (a,b,g,k,l,m)
Thompson Pipe & Steel Co., Colo (g)
Toepfer & Sons., Inc., Wis (a,b,c,e,f,g,h,j)
Wesbar Stamping Corp., Wis (a)
Whitehead Metal Products Co., Inc., NY (a,b,f)
Whyte, Oliver Co., Inc., NY (a,g)
Wire & Iron Products, Inc., Mich (f,g)
Wrought Washer Mfg. Co., Wis (g)

Permanent Mold Castings

(see Castings)

Phenolics

Ace Plastic Co., NY (bb,cc,dd)
Adhesive Products Corp., NY (x)
Alcylite Plastics & Chemical Corp., Calif (p,x,y)
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY (p,y)
American-Marietta Co., Adhesive, Resin & Chemical Div., Wash (p)
Anderson Assoc., Inc., Ohio (y)
Archer-Daniels-Midland Co., Minn (y)
Atlas Mineral Products Co., Pa (x)
Auburn Plastic Engineering, Ill (bb,cc)
Baer, N.S. Co., NJ (bb,cc,dd,ee)
Bisonite Co., Inc., NY (x)
Blank, Arthur & Co., Inc., Mass (cc)
Booty Resineers Div., American-Marietta Co., Ohio (p)
Borden Chemical Div., Borden Co., NY (p)
Cadillac Plastic & Chemical Co., Mich (bb,cc,dd,ee)
Calfibe Co., Inc., Calif (cc,ee)
Catalin Corp. of America, NY (p,x)
Chemical Process Co., Calif (x)
Coast Mfg. & Supply Co., Calif (y)
Colonial Kolonite Co., Ill (bb,cc,ee)
Comco Plastics, Inc., NY (bb,cc,dd,ee)
Commercial Plastics & Supply Corp., NY (bb,cc,dd,ee)
Continental-Diamond Fibre Corp., Del (bb,cc,dd,ee)
Cordo Chemical Corp., Conn (y)
Cordo Molding Products, Inc., Conn (y)
CrystalX Corp., Pa (bb,cc,dd,ee)
Curbell, Inc., NY (bb,cc,dd,ee)
Delta Plastics Co., NJ (bb,cc,dd,ee)
Douglas & Sturgess, Calif (x,y)
Dunnican Assoc., NJ (p,y)
Durez Plastics Div., Hooker Chemical Corp., NY (p,x,y)—Ad pp 232-233
Dyna-Therm Chemical Corp., Calif (p)
Electrofilm, Inc., Calif (t)
Ellay Corp., Md (bb,cc,dd,ee)
Farley & Loetscher Mfg. Co., Plastics Div., Iowa (cc)
Fiberite Corp., Minn (y)—Ad p 281
Fiber Glass Industries, Inc., NY (x,cc)
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass (p,x,y)
Formica Corp., Sub. of American Cyanamid Co., Ohio (bb,cc,dd,ee)
Foss Mfg. Co., Id (x)
Galigher Co., Utah (bb,cc,dd,ee)
General Electric Co., Chemical Materials Dept., Mass (p,x,y)
General Electric Co., Laminated Products Dept., Ohio (bb,cc,ee)
General Plastics Mfg. Co., Wash (bb,cc,dd,ee)
Grigoleit Co., Ill (p,s)
Haveg Industries, Inc., Del (p,bb,cc,ee)
Hercules Powder Co., Inc., Del (p)
Hiller Aircraft Corp., Adhesive Engineering Div., Calif (u)
Iten Fibre Co., Ohio (bb,cc,dd,ee)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Lewis, J.P. Co., Plastic Products Div., NY (cc)
Kish Industries, Inc., Mich (u,x)
Kurz Kasch, Inc., Ohio (y)
Laminated Plastex Corp., Ohio (x,cc)
Maloney, F.H. Co., Tex (x,y,bb,cc,dd,ee)
Marblette Corp., NY (p,u,x,y,bb,cc,ee)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (bb,cc,ee)
Micarta Div., Westinghouse Electric Corp., SC (p,x)
Monsanto Chemical Co., Plastics Div., Mass (p,x)
Narmco Industries, Inc., Narmco Materials Div., Calif (u,x,y,dd)
National Moldite Co., NJ (y)
National Vulcanized Fibre Co., Del (bb,cc,dd,ee)
New England Laminates Co., Inc., Conn (cc)
Nopco Chemical Co., NJ (p)
Norrich Plastics Corp., NY (bb,cc,dd,ee)
Northern Plastics Corp., Wis (cc,dd)
Omni Products Corp., NY (y)
Panelyte Div., St. Regis Paper Co., NJ (x,bb,cc,dd,ee)
Penn Fibre & Specialty Co., Inc., Pa (bb,cc,dd,ee)
Permali, Inc., Pa (bb,cc,dd)
Phillrus Products Co., NJ (bb,cc,dd,ee)
Plastics Engineering Co., Wis (p,x,y,aa)—Ad p 270
Poly Resins, Calif (p,x)
Precision Paper Tube Co., Ill (ee)
Pyrosil Inc., Ohio (x,cc)
Raybestos Div., Raybestos-Manhattan, Inc., Conn (p,x)
Raybestos-Manhattan, Inc., Adhesives Div., Conn (p,x)
Raybestos - Manhattan, Inc., Plastic Products Div., Pa (p,x,y)
Reichhold Chemicals, Inc., NY (p,x,y)
Rezolin, Inc., Calif (p,u,x)
Richardson Co., NY (bb,cc,ee)
Rogers Corp., Conn (y)—Ad p 261
Schenectady Varnish Co., Inc., NY (p,x)
Schwab Plastic Corp., Mich (bb,cc,dd,ee)
Sierra Electric Corp., Calif (y)
Spaulding Fibre Co., Inc., NY (bb,cc,dd,ee)
Spencer Rubber Co., Conn (u)
Strick Plastics Co., Pa (u,cc)
Sun Chemical Corp., Electro Technical Div., NJ (x)
Swedlow, Inc., Calif (cc)
Synco Resins, Inc., Conn (p,x)
Synthane Corp., Pa (bb,cc,dd,ee)
Taylor Fibre Co., Pa (bb,cc,dd,ee)
Texas Glass Fiber Corp., Tex (y)
Thombert, Inc., Iowa (bb,cc,dd,ee)
Union Carbide Plastics Co., Div. of Union Carbide Corp., NY (p,u,x,y)—Ad p 257
U.S. Polymeric Chemicals, Inc., Conn (s)
Varcum Chemical Corp., NY (p)
Watertown Mfg. Co., Conn (p,y)
Westlake Plastics Co., Pa (bb,cc,dd,ee)
Wilmington Fibre Specialty Co., Del (bb,cc,ee)

Phosphate Coatings

(see Conversion Coatings)

Phosphor Bronze

(see Copper)

Pipe

(see Tubing)

Plaster Mold Castings

(see Castings)

Plastics

(see specific material and form)

Plate

(see specific metal)

Plated Coatings

(see Electroplated Coatings; Preplated Metals)

Platinum and Platinum Group Alloys

American Metal Climax, Inc., NY (aa)
American Platinum & Silver Div., Engelhard Industries, Inc., NY (n,v,z,aa,bb,cc,dd,ee,ff)
American Platinum Works, NJ (z)
American Silver Co., NY (v,dd,ee,ff)
Anaconda Co., NY (n,v,cc)
Baker & Co., Inc., NJ (n,o,v,w,z,aa,bb,cc,dd)
Bishop, J. & Co. Platinum Works, Pa (n,v,z,bb,cc,dd,ee,ff)
Deringer Metallurgical Corp., Ill (cc,dd,ee,ff)
Eastern Smelting & Refining Corp., Mass (n,o,v,w,z,aa,bb,cc,dd,ee,ff)
Electronic Parts Mfg. Co., Inc., NJ (ff)
Gibson Electric Co., Pa (bb,dd,ff)—Ad p 466
Goldsmith Bros. Div., National Lead Co., Ill (n,o,v,w,z,bb,cc,dd,ff)
Hagstoz, T.B. & Son, Pa (n,cc,dd,ff)
Hamilton Watch Co., Precision Metals Div., Pa (ff)
Handy & Harman, NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Hanovia Chemical & Mfg. Co., NJ (aa)
Hardy, Charles, Inc., Mass (aa)
Hayden Wine Works, Inc., Mass (ff)
Hudsar, Inc., NJ (w)
International Nickel Co., Inc., Platinum Metals Div., NY —Ad pp 182-183
Leach & Garner Co., Industrial Div., Mass (n,o,v,bb,cc,dd,ee,ff)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (o,dd,ee,ff)
Metz Refining Co., NJ (n,o,q,z,aa,bb,cc,dd,ee,ff)
Nesor Alloy Products Co., NJ (dd,ff)
Ney, J.M. Co., Industrial Div., Conn (z,bb,cc,dd,ff)
Nuclear Metals, Inc., Mass (w)
Sel-Rex Corp., NJ (n,aa)—Ad p 356
Standard Metals Corp., Mass (cc,dd,ff)
Texas Instruments, Inc., Metals & Controls Div., Mass (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Technic, Inc., RI (aa)—Ad p 352
Western Gold & Platinum Co., Sub. of Wilbur B. Driver Co., Calif (aa,cc,dd,ff)
Wildberg Bros. Smelting & Refining Co., Calif (n,o,v,w,z,aa,bb,cc,dd,ff)
Williams Gold Refining Co., Inc., NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Wilson H.A. Div., Engelhard Industries, Inc., NJ (ff)

Plywood

(see Wood)

Polyamides

(nylon)

Ace Plastics Co., NY (bb,dd)
Adhesive Products Corp., NY (x)
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY (p,s,y)
American Hard Rubber Co., Div. of Amerace Corp., NJ (bb,dd,ee)
American Molding Powder & Chemical Co., NY (y)
Anchor Plastics Co., Inc., NY (bb,dd,ee)
Anderson Asso., Inc., Ohio (y)
Auburn Plastic Engineering, Ill (t,bb,cc,ee)
Bamberger, Claude P., Inc., NJ (y)
Belding Corticelli Industries, NY (p,x,y)
Cadillac Plastic & Chemical Co., Mich (f,bb,cc,dd,ee)
Catalin Corp. of America, NY (y)
Chemical Coatings & Engineering Co., Inc., Pa (x)
Chippewa Plastics Co., Wis (t)
Colonial Kolonite Co., Ill (bb,cc,dd,ee)
Commercial Plastics & Supply Corp., NY (bb,cc,dd)
Conneaut Rubber and Plastics Co., Div. of U.S. Stoneware Co., Ohio (bb,cc,dd,ee)
Cosmo Plastics Co., Ohio (u)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Danielson Mfg. Co., Conn (bb,cc,dd,ee)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

du Pont de Nemours, E. I. & Co., Inc., Del (p,s,y)
Dyna-Therm Chemical Corp., Calif (p)
Emerson & Cuming, Inc., Mass (p,u,x)
Fiberfil, Inc., Ind (y)
Firestone Plastics Co., Pa (s)
Flexible Tubing Corp., Conn (ee)
Fluoro-Plastics, Inc., Div. of Flexrock Co., Pa (bb,cc)
Foster Grant Co., Mass (p,t,y,ee)
Fox Edge Co., Inc., Mass (s)
Fry Plastics International, Calif (bb, cc)
General Mills Inc., Chemical Div., Ill (p)
General Plastics Corp., NJ (t,x)
General Plastics Mfg. Co., Wash (bb, cc,dd,ee)
Glass Laboratories, NY (bb,dd,ee)
H & R Industries, Pa (t,bb,cc,dd,ee)
Hauger-Beegle Asso., Inc., Ill (t)
Hyde Co., A.L., NJ (bb,cc)
Industrial Rayon Corp., NY (s)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Lus-Trus Corp., Mich (cc,ee)
Moore, Samuel & Co., Ohio (ee)
Muehlstein, H. & Co., Inc., NY (y)
Narmco Industries, Inc., Narmco Materials Div., Calif (x,y)
National Vulcanized Fibre Co., Del (bb,dd,ee)
Plast-Ad Mfg. Co., Ind (bb,cc,dd,ee)
Polymer Corp. of Pennsylvania, Sub. of Polymer Corp., Pa
(t,bb,cc,dd,ee)—Ad p 230
Prince Rubber & Plastics Co., Inc., NY (bb,ee)
Raybestos - Manhattan, Inc., Plastic Products Div., Pa (x)
Reichhold Chemicals, Inc., NY (p)
Schwab Plastic Corp., Mich (bb,cc,dd, ee)
Shamban, W.S. & Co., Calif (t,bb,cc, dd,ee)
Southern Plastics Co., SC (bb,cc,dd, ee)
Spencer Chemical Co., Mo (p,x,y)
Sunlites Plastics, Inc., Wis (bb,dd,ee)
Thombert, Inc., Iowa (bb,cc,dd,ee)
U. S. Gasket Plastics Div., Garlock Packing Co., NJ (t,bb,cc,dd,ee)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (bb,dd,ee)
Western Plastics Corp., Neb (bb,dd,ee)
Westlake Plastics Co., Pa (t,bb,cc,dd, ee)

Polycarbonate Plastics

Commercial Plastics & Supply Corp., NY (bb,cc,dd,ee)
Fiberfil, Inc., Ind (y)
General Electric Co., NY (p,y)
General Electric Co., Chemical Materials Dept., Mass (p,t,y)
Glass Laboratories Inc., NY (bb,dd,ee)
Mobay Chemical Co., Pa (p,t,y)
Pennsylvania Fluorocarbon Co., Inc., Pa (ee)
Polymer Corp., Pa (y)
Polymer Corp. of Pennsylvania, Sub. of Polymer Corp., Pa (bb,cc,dd,ee)
Southern Plastics Co., SC (bb,cc,dd,ee)
Visking Co., Div. of Union Carbide Corp., Ill (t)

Polyesters

Adhesive Products Corp., NY (x)
Aerojet-General Corp., Structural Materials Div., Calif (y)
Alcylite Plastics & Chemical Corp., Calif (p)
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY (p,y)
Alsynite Co. of America, Calif (cc)
American Cynamid Co., Plastics & Resins Div., NY
(x)—Ad pp 251-254
American Metaseal Corp., NJ (p)
American Products Mfg. Co., Inc., La (p)
Archer-Daniels-Midland Co., Minn (p)
Atlas Mineral Products Co., Pa (x)
Atlas Powder Co., Chemicals Div., Del
(p,x,y)—Ad p 262
Auburn Plastic Engineering, Ill (t,bb, cc,ee)
Avery Label Co., Decorative Products Div., Ohio (t)
Boonton Molding Co., NJ (x)
Brown Rubber Co., Inc., Ind (u)
Burkart, F. Mfg. Co., Div. of Textron Inc., Mo (u)
Cadillac Plastic & Chemical Co., Mich (t,x,cc)
Calfibe Co., Inc., Calif (cc,ee)
Cast Optics Corp., NJ (cc)
Celanese Plastics Co. Div., Celanese Corp. of America, NJ
(p)—Ad pp 271-274
Chemical Process Co., Calif (p,x,y)
Coating Products, Inc., NJ
(t,cc)—Ad p 359
Colonial Kolonite Co., Ill (cc)
Columbia - Geneva Steel Div., U.S. Steel Corp., Calif (ee)
Continental-Diamond Fibre Corp., Del (bb,cc,dd,ee)
Cordo Chemical Corp., Conn (x,y)
Cordo Molding Products, Inc., Conn (y)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Curbell, Inc., NY (f)
Dayton Rubber Co., Ohio (x,y)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
Douglas & Sturgess, Calif (x,y) (s,t)
du Pont de Nemours, E. I. & Co., Inc., Del (s,t)
Durez Plastics Div., Hooker Chemical Corp., NY
(p,x,y)—Ad pp 232-233
Everlite Corp., Wash (cc)
Fiber Glass Industries, Inc., NY (x,y, cc)
Fiberglass Ohio Inc., Ohio (cc)
Flexfirm Products, Calif (s,y)
Flexible Tubing Corp., Conn (ee)
Foam Products, Inc., Pa (u)
Foamade Industries, Mich (u)
Foss Mfg. Co., Id (x)
Fry Plastics International, Calif (p,x)
Galigher Co., Utah (p,s,x)
General Electric Co., NY (x)
General Plastics Mfg. Co., Wash (x, cc)
General Tire & Rubber Co., Chemical Div., Ohio (p)
Glass Reinforced Plastics Corp., Ohio (bb,ee)
Glastic Corp., Ohio (y,bb,cc)
Goodrich, B.F. Co., Sponge Products Div., Conn (u)
Goodyear Tire & Rubber Co., Chemical Div., Ohio (p)
Hall, C.P. Co., Ohio (p)
Haskelite Mfg. Corp., Mich (cc,dd)
Hastings & Co., Inc., Pa (t)
Haveg Industries, Inc., Del (cc)
Hays Mfg. Co., Pa (y,cc)
Industrial Paint Div., Glidden Co., Ohio
(p,x)—Ad p 248
Insulation Mfrs. Corp., Ill (cc,dd)
Interchemical Corp., NY (p,x,y)
Interchemical Corp., Finishes Div., NJ (p,x)
Johns-Manville Corp., NY (cc)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Kish Industries, Inc., Mich (x)
Laminated Plastex Corp., Ohio (x,cc)
Lewis, G.B. Co., Wis (bb)
Luminous Resins, Inc., Ill (y)
Maloney, F.H. Co., Tex (x,y)
Micarta Div., Westinghouse Electric Corp., SC (p,y)
Minnesota Mining & Mfg. Co., Minn (s)
Mobay Chemical Co., Mo (p)
Muehlstein, H. & Co., Inc., NY (p)
Narmco Industries, Inc., Narmco Materials Div., Calif (x,y,dd)
National Vulcanized Fibre Co., Del (cc,dd)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (p,u,x,y)
Nopco Chemical Co., NJ (p)
Omni Products Corp., NY (p)
Ormond Mfg. Co., Inc., NJ (cc,dd)
Panelyte Div., St. Regis Paper Co., NJ (x,y,cc)
Peiron Corp., Ill (p,x,y)
Penn Fibre & Specialty Co., Inc., Pa (cc)
Philrus Products Co., NJ (bb,cc,dd)
PittsLurgh Plate Glass Co., Pa (p,u, x,y)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (x)
Plumb Chemical Corp., Pa (y)
Polycast Corp., Conn (cc)
Polygon Plastic Co., Ind (bb,ee)
Porter, William Co., Calif (ee)
Precision Paper Tube Co., Ill (ee)
Prince Rubber & Plastics Co., Inc., NY (cc)
Reichhold Chemicals, Inc., NY (p,u,x)
Robertson, H.H. Co., Pa (p)
Rohm & Haas Co., Pa (x,y)
Roller Reinforced Plastics, Ohio (x,y)
Rubber Corp. of America, NY (u)
Schori Process Div., Ferro-Co Corp., NY (cc,ee)
Schwab Plastic Corp., Mich (u)
Schwartz Chemical Co., Inc., NY (x)
Sheller Mfg. Corp., Mich (u)
Specialty Resins Co., Calif (p,x)
Strick Plastics Co., Pa (u,cc,dd)
Sun Chemical Corp., Electro Technical Div., NJ (p,x)
Swedlow, Inc., Calif (cc)
Thalco, Calif (p)
United Shoe Machinery Corp., Mass (x)
U.S. Polymeric Chemicals, Inc., Conn (s)
U.S. Rubber Co., NY (p,u,x)
Varflex Corp., NY (ee)
Wasco Products, Inc., Mass (cc)
Williamson Adhesives, Inc., Ill (y)
Witco Chemical Co., Ill (p,u)
Woodall Industries, Inc., Mich (y)
Zenith Plastics Co., Sub. of Minnesota Mining & Mfg. Co., Calif (u)

Polyethylenes

aaRBee Plastic Co., Calif (y)
Ace Plastic Co., NY (bb,cc,dd,ee)
Adhesive Products Corp., NY (x)
Advance Screw Products Co., Inc., Wis (bb)
Aladdin Transparent Packaging Corp., NY (t,ee)
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY (p,y)
Allied Resinous Products, Inc., Ohio (y,bb,cc,dd,ee)
Alpha Wire Corp., NY (ee)
American Agile Corp., Ohio (bb,cc,dd, ee)
American Hard Rubber Co., Div. of Amerace Corp., NY (bb,dd)
American Molding Powder & Chemical Co., NY (y)
Anchor Plastics Co., Inc., NY (bb,dd, ee)
Anderson Asso., Inc., Ohio (y)
Anesit Co., Ill (ee)
Auburn Plastic Engineering, Ill (t,bb, cc,ee)
Auburn Plastics Inc., NY (bb,cc,dd,ee)
Bamberger, Claude P., Inc., NJ (p,y)
Blacher, B., NY (t)
Blank, Arthur & Co., Inc., Mass (t)
Blossom Mfg. Co., Inc., NY (t,cc)
Bolta Products Div., General Tire & Rubber Co., Mass (s)
Cadillac Plastic & Chemical Co., Mich (t,bb,cc,dd,ee)
Campco Div., Chicago Molded Products Corp., Ill
(t,cc)—Ad p 243
Carroll, J.B. Co., Ill (cc)
Catalin Corp. of America, NY (y)
Celanese Plastics Co., Div. of Celanese Corp. of America, NJ
(p,t,y,cc)—Ad pp 271-274
Celluplastic Corp., NJ (bb,ee)
Chester Packaging Div., St. Regis Paper Co., NY (t,cc)
Chippewa Plastics Co., Wis (t,ee)
Clopay Corp., Ohio (t,cc)
Clover Industries, Inc., NY (y)
Colonial Kolonite Co., Ill (bb,cc,ee)
Commercial Plastics & Supply Corp., NY (bb,cc,dd,ee)
Conneaut Rubber & Plastics Co., Div. of U.S. Stoneware Co., Ohio (t,bb, cc,dd,ee)
Contour Extrusion Co., NY (t,bb,cc,dd, ee)
Copper and Brass Sales, Inc., Mich (ee)
Cosmo Plastics Co., Ohio (u)
Crane Plastics, Inc., Ohio (bb,dd,ee)
Crescent Plastics, Inc., Ind (ee)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Curbell, Inc., NY (s,bb,cc,dd,ee)
Danielson Mfg. Co., Conn (bb)
Dapol Plastics, Inc., Mass (y)
Davis, Joseph Plastics Co., NJ (t,y, bb,cc,dd,ee)
Denver Plastics, Inc., Colo (t,u,bb,cc, dd,ee)
Designers Metal Corp., Ill (cc)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
Dow Chemical Co., Plastics Div., Mich (p,t,y)
du Pont de Nemours, E. I. & Co., Inc., Del (p,y)
Dura-Lee Corp., Kan (t)
Durable Formed Products, Inc., NY (cc,ee)
Durethene Corp., Ill (t)
Eastman Chemical Products, Inc., Sub. of Eastman Kodak Co., NY (p,u,y)
Eclipse Plastic Industries, Inc., Fla (bb,cc,dd,ee)
Extruders, Inc., Calif (t)
Firestone Plastics Co., Pa (s,t)
Flexible Packaging Div., Continental Can Co., Inc., Ohio (t,cc)
Foamade Industries, Mich (u,cc,dd)
Foss Mfg. Co., Id (t)
Foster Grant Co., Mass (t)
Fox Edge Co., Inc., Mass (s)
Galigher Co., Utah (bb,cc,dd,ee)
Garlock Packing Co., NY (y)
Geauga Industries Co., Ohio (bb,dd)
General Electric Co., NY (t)
General Gasket, Inc., Conn (t,cc)
General Plastics Corp., Ind (cc)
General Plastics Mfg. Co., Wash (cc)
General Tire & Rubber Co., Ind (t,cc)
Genesee Laboratory, Inc., NY (ee)
Gering Plastics, Div. of Studebaker-Packard Corp., NJ (t,y,bb,dd,ee)
Glass Laboratories, NY (bb,dd,ee)
Goodrich-Gulf Chemicals, Inc., Ohio (p)
Grace, W.R. & Co., Polymer Chemicals Div., NJ (p,y)
Grigoleit Co., Ill (p,s)
H & R Industries, Pa (t,bb,cc,dd,ee)
Hastings & Co., Inc., Pa (t)
Hercules Powder Co., Inc., Del (p,y)
Heyden Newport Chemical Corp., American Plastics Corp. Div., NY (bb,cc,ee)
Hydrawlik Co., NJ (bb,dd)
Industrial Plastics Corp., Ind (bb,dd)
Insulation Mfrs. Corp., Ill (cc,ee)
Jet Specialties Co., Inc., Calif (bb,cc, dd,ee)
KSH Plastics, Inc., Mo (bb,cc,dd)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Kaykor Industries, Inc., Div. of Kaye-Tex Mfg. Corp., NJ (cc)
Koppers Co., Inc., Plastics Div., Pa (p,y)
Kuss, R.L. & Co., Inc., Ohio (t)
Ludlow Plastics, Mass (t)
Luminous Resins, Inc., Ill (y)
Lus-Trus Corp., Mich (cc,ee)
Maloney, F.H. Co., Tex (y)
Manufacturers Corp., Ohio (ee)
Mason Envelope Co., Inc., NY (t)
Mayon Plastics, Minn (ee)
Midwest Plastic Products Co., Ill (t, cc)

Monsanto Chemical Co., Plastics Div., Mass (p,y)
Moore, Samuel & Co.,Ohio (ee)
Muehlstein, H & Co., Inc., NY (y)
Murray, A.B. Co., Inc., NJ (ee)
Nalge Co., Inc., NY (ee)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
National Tube Div., U.S. Steel Corp., Pa (ee)
New England Tape Co., Div. of United-Carr Fastener Corp., Mass (dd)
Olin Mathieson Chemical Corp., Packaging Div., NY (t,ee)
Omni Products Corp., NY (y)
Ormond Mfg. Co., Inc., NJ (cc,dd)
Pacific Coast Foil Co., Calif (t)
Panelyte Div., St. Regis Paper Co., NJ (t,cc,ee)
Penn Fibre & Specialty Co., Inc., Pa (bb,cc,dd,ee)
Perfex Plastics, Inc., III (bb,dd,ee)
Phillips Chemical Co., Okla (p)
Plastic Compounding Corp., Sub. of Plastiglide Mfg. Co., Calif (y)
Plastic Materials, Inc., NY (y)
Plastic Packaging Co., III (t)
Plax Corp., Conn (t,cc)
Polo Plastics Co., Wis (t)
Polymer Corp., Pa (y)
Polyplastic Products, Inc., NJ (t,cc)
Precision Paper Tube Co., III (cc)
Presto Plastic Products Co., Inc., NY (t,cc)
Prince Rubber & Plastics Co., Inc., NY (bb,cc,dd,ee)
Pyramid Industries, Inc., Pa (ee)
Pyramid Plastics, Inc., III (dd,ee)
Reed Plastics Corp., Mass (y)
Reliance Plastic & Chemical Corp., NJ (t,bb,dd)
Reynolds Aluminum Supply Co., Ga (t)
Reynolds Metals Co., Va (t,cc)
Ross & Roberts, Inc., Conn (t)
Rubber & Plastics Compound Co., Inc., NY (t)
Russell Mfg. Co., Conn (s)
Ryerson, Joseph T. & Son, Inc., III (ee)
Schwab Plastic Corp., Mich (u,bb,cc, dd,ee)
Scranton Plastic Laminating Corp., Pa (cc)
Seiberling Rubber Co., Plastics Div., Ohio (bb,cc)
Shaw-Kendall Engineering Co., Ohio (ee)
Sheller Mfg. Corp., Mich (u)
Simon Products Co., III (t)
Snyder Mfg. Co., Inc., Ohio (t,cc)
Southern Plastics Co., SC (bb,cc,dd,ee)
Spencer Chemical Co., Mo (p,x,y)
Staver Co., Inc., NY (cc,dd)
Sunlites Plastics, Inc., Wis (bb,dd,ee)
Superior Mfg. Co., Pa (dd)
Superior Plastics, Inc., III (bb,cc,dd, ee)
Supplex Co., Div. of Amerace Corp., NJ (y,dd,ee)
Technical Tape Corp., NY (t,cc,ee)
Thombert, Inc., Iowa (cc,ee)
Triangle Conduit & Cable Co., Inc., NJ (ee)
Toyad Corp., Pa
(u)—Ad p 260
Union Carbide Plastics Co., Div. of Union Carbide Corp., NY
(p,y)—Ad p 257
U.S. Industrial Chemicals Co., Div. of National Distillers & Chemical Corp., NY (p,x,y)
U.S. Stoneware Co., NY (y)
Varflex Corp., NY (ee)
Visking Co., Div. of Union Carbide Corp., III (t)
Vogt Mfg. Corp., NY (bb,dd)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (s,bb,dd,ee)
Western Felt Works, III (cc)
Western Plastics Corp., Neb (bb,dd,ee)
Western Plastics Corp., Wash (ee)
Westlake Plastics Co., Pa (t,bb,cc,dd, ee)
William Brand-Rex Div., American Enka Corp., Mass (ee)
Woodall Industries, Inc., Mich (cc)
World Plastics, NY (bb,cc,dd,ee)

Polypropylene

Avi Sun Corp., Pa
(y)—Ad pp 244-245
Campco Div., Chicago Molded Products Corp., III
(t,cc)—Ad p 243
Catalin Corp. of America, NY (y)
Chemore Corp., NY (p,s,y)
Chippewa Plastics Co., Wis (t)
Conneaut Rubber and Plastics Co., Div. of U. S. Stoneware Co., Ohio (bb,cc,dd,ee)
Crane Plastics, Inc., Ohio (bb,dd,ee)
Eastman Chemical Products, Inc., Sub. of Eastman Kodak Co., NY (p,y)
Enjay Chemical Co. Div., Humble Oil & Refining Co., NY (y)
Hercules Powder Co., Del (y)
Industrial Rayon Corp., NY (s)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Ludlow Plastics, Mass (t)
Madin Plastics Inc., NJ (y,cc)
Nalge Co., Inc., NY (ee)
Spencer Chemical Co., Mo (y)
Texas Eastman Co., Div. of Eastman Kodak Co., Tex (y)
Visking Co., Div. of Union Carbide Corp., III (t)

Polystyrenes

(incl. copolymers and modifications)

aaRBee Plastic Co., Calif (y)
Ace Plastic Co., NY (bb,cc,dd,ee)
Adhesive Products Corp., NY (x)
Ambassador Plastics & Mfg. Corp., III (u)
American Cyanamid Co., Plastics & Resins Div., NY (y)
American Hard Rubber Co., Div. of Amerace Corp., NJ (bb,cc,dd,ee)
Anchor Plastics Co., Inc., NY (bb,dd, ee)
Anderson Asso., Inc., Ohio (y)
Anesit Co., III (ee)
Auburn Plastic Engineering, III (bb,cc, ee)
Auburn Plastics, Inc., NY (bb,cc,dd, ee)
Bamberger, Claude P., Inc., NJ (p,y)
Blank, Arthur & Co., Inc., Mass (cc)
Bolta Products Div., General Tire & Rubber Co., Mass (t,cc)
Cadillac Plastic & Chemical Co., Mich (bb,cc,dd,ee)
Campco Div., Chicago Molded Products Corp., III
(t,cc)—Ad p 243
Catalin Corp. of America, NY (y)
Chemical Development Corp., Mass (p)
Coating Products, Inc., NJ (t,cc)
Colonial Kolonite Co., III (bb,cc,ee)
Commercial Plastics & Supply Corp., NY (bb,cc,dd)
Conneaut Rubber & Plastics Co., Div. of U.S. Stoneware Co., Ohio (bb, cc,dd,ee)
Cosmo Plastics Co., Ohio (u)
Crane Plastics, Inc., Ohio (bb,dd,ee)
Crescent Plastics, Inc., Ind (ee)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Curbell, Inc., NY (bb,cc,ee)
Dapol Plastics, Inc., Mass (y)
Denver Plastics, Inc., Colo (u)
Dewey & Almy Chemical Co., Div. of W.R. Grace Co., Mass (p)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
Dow Chemical Co., Plastics Div., Mich (p,t,u,y)
Dryden Rubber Div., Sheller Mfg. Corp., III (y)
Dumont Corp., Calif (u)
Dura Plastics of New York, Inc., NY (bb,cc)
Dyna-Therm Chemical Corp., Calif (p)
Eclipse Plastic Industries, Inc., Fla (bb,cc,dd,ee)
Emerson & Cuming, Inc., Mass (u,x,bb)
Fiberfil, Inc., Ind (y)
Foam Products, Inc., Pa
Foster Grant Co., Mass (p,s,y,cc)
Fry Plastics International, Calif (cc)
Galigher Co., Utah (bb,cc,dd,ee)
General Plastics Corp., Ind (cc)
General Plastics Mfg. Co., Wash (bb, cc,dd,ee)
Gering Plastics, Div. of Studebaker-Packard Corp., NJ (y,bb,dd,ee)
Glass Laboratories, NY (bb,dd,ee)
Glo-Brite Products, Inc., III (u,y,cc)
Goodyear Tire & Rubber Co., Ohio (y)
H & R Industries, Pa (bb,cc,dd,ee)
Haskelite Mfg Corp., Mich (u)
Hayden Wire Works, Inc., Mass (x)
Heyden Newport Chemical Corp., American Plastics Corp. Div., NY (bb, cc,dd,ee)
Industrial Plastics Corp., Ind (bb,dd)
KSH Plastics Inc., Mo (bb,cc,dd)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Kaykor Industries, Inc., NJ (cc)
Koppers Co., Plastics Div., Pa
(p,u,y)—Ad pp 264-265
Laminated Plastex Corp., Ohio (x,cc)
Lone Star Plastics Co., Inc., Tex (u)
Luminous Resins, Inc., III (y)
Lus-Trus Corp., Mich (cc,ee)
Maloney, F.H. Co., Tex (x,y)
Manufacturers Corp., Ohio (ee)
Marbon Chemical Div., Borg-Warner Corp., Ind (p,y)
Midwest Plastic Products Co., III (t, cc)
Monsanto Chemical Co., Mass (p,y)
Muehlstein, H. & Co., Inc., NY (p,y)
Murray, A.B. Co., Inc., NJ (ee)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (p,y)
Nesbitt Industries, Inc., III (u)
Nixon Nitration Works, NJ (cc)
Northwest Plastics Industries, Inc., Wash (u)
Omni Products Corp., NY (y)
O'Sullivan Rubber Corp., Plastics Div., Va (t,cc)
Panelyte Div., St. Regis Paper Co., NJ (u,bb,cc)
Perfex Plastics, Inc., III (bb,dd,ee)
Plastic Materials, Inc., NY (y)
Plax Corp., Conn (t,cc)
Polymer Corp. of Pennsylvania, Sub. of Polymer Corp., Pa (bb,cc)
Precision Paper Tube Co., III (ee)
Prince Rubber & Plastics Co., Inc., NY (bb,cc,ee)
Pyramid Plastics, Inc., III (dd,ee)
Reed Plastics Corp., Mass (y)
Schwab Plastic Corp., Mich (u,bb,cc, dd,ee)
Scranton Plastic Laminating Corp., Pa (cc)
Seiberling Rubber Co., Plastics Div., Ohio (bb,cc)
Sheffield Plastics Co., Mass (cc)
Sheller Mfg. Corp., Mich (u)
Snyder Mfg. Co., Inc., Ohio (t,cc)
Southern Plastics Co., SC (bb,cc,dd,ee)
Sterling Models, Pa (u)
Strick Plastics Co., Pa (u)
Sunlites Plastics, Inc., Wis (bb,dd,ee)
Superior Plastics, Inc., III (bb,cc,dd, ee)
Toyad Corp., Pa
(u)—Ad p 260
Union Carbide Plastics Co., Div. of Union Carbide Corp., NY
(p,y)—Ad p 257
United Shoe Machinery Corp., Mass (p,u)
Visking Co., Div. of Union Carbide Corp., III (t)
Western Felt Works, III (cc)
Western Plastics Corp., Neb (bb,dd,ee)
Western Plastics Corp., Wash (ee)
Westlake Plastics Co., Pa (t,y,bb,cc, dd,ee)
William Brand-Rex Div., American Enka Corp., Mass (bb,cc)
Woodall Industries, Inc., Mich (cc)
Worcester Moulded Plastics Co., Mass (u)
World Plastics, NY (bb,cc,dd,ee)

Polysulfide Rubber

Adhesive Products Corp., NY (x)
Armstrong Cork Co., Pa (bb,cc,dd)
Belko Corp., Md (y)
Bond International, Inc., Mich (y,ee)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chemical Coatings & Engineering Co., Inc., Pa (x,y)
Chicago-Allis Mfg. Corp., III (p)
Coast Pro-Seal Mfg. Co., Calif (y)
Dayton Rubber Co., Ohio (y,bb,cc,dd, ee)
Garlock Packing Co., NY (y,cc)
Hiller Aircraft Corp., Adhesive Engineering Div., Calif (x)
Home Rubber Co., NJ (y,bb,cc,dd)
Maloney, F.H. Co., Tex (y)
Moxness Products, Inc., Wis (bb,cc, dd,ee)
Paeco Rubber Co., Inc., Ohio (y,dd,ee)
Parker Seal Co., Div. of Parker-Hannifin Corp., Calif (u)
Parker, Stearns & Co., Inc., NY (y, bb,cc,dd,ee)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (x)
Polymer Industries Inc., Conn (x)
Raybestos-Manhattan, Inc., Plastic Products Div., Pa (x)
Thiokol Chemical Corp., NJ (p,x,y)
Toyad Corp., Pa (u)
Trostel, Albert Packing, Ltd., Wis (y)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (p,y,cc)
Vulcanized Rubber & Plastics Co., Pa (y)
Western Felt Works, Ill (y,cc,dd,ee)
Williams-Bowman Rubber Co., Ill (y,bb,cc,dd,ee)

Polyvinyl Alcohols

(see Vinyls)

Polyvinyl Chloride and Copolymers

(see Vinyls)

Porcelain

(see Ceramics)

Porcelain Enamels

(see Inorganic Coatings)

Powdered Metals

(see Iron Powders or specific metal)

Precoated Metals —Aluminized

American Chain & Cable Co., Pa (g)
Armco Steel Corp., Ohio (g)
Bethlehem Steel Co., Pa (g)
Biersach & Niedermeyer Co., Wis (a)
Brasco Mfg. Co., Ill (g)
Clad-Rex Corp., Ill (a,g)
Colonial Alloys Co., Pa. (a)
Enamel Products Co., Ohio (g)
Gillett & Eaton, Inc., Minn (c)
Grigoleit Co., Ill (a)
Ideal Can Co., Mass (g)
Jackson Steel Products, Inc., NY (g)
Kassel Export Co., Inc., NJ (c,g)
Kees, F.D. Mfg. Co., Neb (g)
Mayville Metal Products Co., Wis (g)
National Galvanizing Co., Pa (g)
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa (g)
Rome Mfg. Div., Revere Copper & Brass, Inc., NY (g)
Sager Metal Strip Co., Ill (a)
Sun Steel Co., Ill (g)
Tickle, Arthur Engineering Works, Inc., NY (c,g)
Whitehead Metal Products Co., Inc., NY (g)
Whyte, Oliver Co., Inc., Mass (g)

Precoated Metals —Galvanized

Albert Pipe Supply Co., Inc., NY (g)
Anderson-Bolling Mfg. Co., Mich (g)
Armco Steel Corp., Ohio (g)
Associated Spring Corp., Wallace Barnes Div., Conn (g)
Atlantic Steel Co., Ga (g)
Bethlehem Steel Co., Pa (c,g)
Biersach & Niedermeyer Co., Wis (g)
Bignall Co., NY (c)
Brasco Mfg. Co., Ill (g)
Brewer-Titchener, Corp., NY (g)
Byers, A.M. Co., Pa (c)
Castle, A.M. & Co., Ill (a,g)
Clad-Rex Corp., Ill (g)
Columbia - Geneva Steel Div., U.S. Steel Corp., Calif (g)
Conner Mfg. Co., Ky (g)
Continental Nu-Steel Metal Products Div., Continental Wire & Iron Works, Ill (g)
Continental Steel Corp., Ind (g)
Edgcomb Steel & Aluminum Corp., NJ (g)
Empire-Reeves Steel Div., Universal-Cyclops Steel Corp., Pa (g)
Enterprise Galvanizing Co., Pa (g)
Grand Sheet Metal Products Co., Consumer Products Div., Ill (c)
Granite City Steel Co., Ill (g)
Hobbs, Clinton E. Co., Mass (c,g)
Ideal Can Co., Mass (g)
Jackson Steel Products, Inc., NY (g)
Kelley Mfg. Co., Tex (g)
Koehler Mfg. Co., Mass (c,g)
Levinson Steel Co., Pa (g)
Mahon, R.C. Co., Mich (g)
Mayville Metal Products Co., Wis (g)
McNally Pittsburg Mfg. Co., Kan (g)
National Galvanizing Co., Pa (g)
National Tube Div., U.S. Steel Corp., Pa (g)
New York Iron Roofing & Corrugating Co., Inc., NJ (g)
Newport Steel Corp., Ky (g)
Nikoh Tube Co., Ill (g)
Northwestern Steel & Wire Co., Ill (g)
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa (g)
Republic Steel Corp., Ohio (g)—Ad pp 84-85
Riverside Foundry & Galvanizing Co., Mich (c,g)
Roebling's John A. Sons Div., Colorado Fuel & Iron Corp., NJ (g)
Rome Mfg. Div., Revere Copper & Brass, Inc., NY (g)
Ryerson, Joseph T. & Son, Inc., Ill (g)
Sharon Steel Corp., Pa (g)
Sherman & Reilly, Inc., Tenn (e,f,g)
Solar Steel Corp., Ohio (g)
Southern Galvanizing Co., Md (g)
Southern Metal Products Co., La (g)
Stainless and Strip Div., Jones & Laughlin Steel Corp., Ohio (g)
Stenman, Bror F., Mass (g)
Sun Steel Co., Ill (g)
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (g)
Thomas Strip Div., Pittsburgh Steel Co., Pa (g)
U. S. Steel Corp., Pa (g)
U.S. Steel Supply Div., U.S. Steel Corp., Ill (g)
Vulcan Rail & Construction Co., NY (g)
Weirton Steel Co., Div. of National Steel Corp., W. Va (g)
Wesbar Stamping Corp., Wis (c,g)
Wheeling Steel Corp., W.Va (g)
Witt Cornice Co., Galvanizing Div., Ohio (g)
Worcester Wire Works Div., National-Standard Co., Mass (g)
Youngstown Kitchens Div., American Standard Co., Ohio (a,g)
Youngstown Sheet & Tube Co., Ohio (g)

Precoated Metals —Lead or Terne-Coated

Acme Stamping & Wire Forming Co., Pa (a,b,g)
Anderson-Bolling Mfg. Co., Mich (g)
Armco Steel Corp., Ohio (c,g)
Biersach & Niedermeyer Co., Wis (g)
Brasco Mfg. Co., Ill (g)
Cartwright, R. Tube Products Co., Mich (g)
Caspers Tin Plate Co., Ill (g)
Columbia - Geneva Steel Div., U.S. Steel Corp., Calif (g)
Composite Industrial Metals, Inc., RI (a,b,c,d,e,f,g,h,j)
Empire-Reeves Steel Div., Universal-Cyclops Steel Corp., Pa (g)
Follansbee Steel Corp., Sheet Metal Specialty Div., W.Va (g)
Hayden Wire Works, Inc., Mass (d)
Higbie Mfg. Co., Mich (g)
Houston Blow Pipe & Sheet Metal Works, Tex (g)
Ideal Can Co., Mass (g)
Langsenkamp, F.H. Co., Ind (b)
National Lead Construction Co., Inc., NJ (d)
New Haven Copper Co., Conn (b)
Nikoh Tube Co., Ill (g)
Philadelphia Steel & Wire Corp., Pa (g)
Presswork, Inc., Mich (b,g)
Reactive Metals, Inc., Ohio (g)
Republic Steel Corp., Ohio (g)—Ad pp 84-85
Revere Copper & Brass, Inc., NY (b)
Rome Mfg. Co., Revere Copper & Brass, Inc., NY (g)
Ryerson, Joseph T. & Son, Inc., (g)
Sharon Steel Corp., Pa (g)
Solar Steel Corp., Ohio (g)
Steel Protection & Chemical Co., Ind (a,b,c,f,g)
Sun Steel Co., Ill (g)
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (g)
Thomas Strip Div., Pittsburgh Steel Co., Pa (g)
U.S. Steel Supply Div., U.S. Steel Corp., Ill (g)
Wayne Foundry & Stamping Co., Mich (g)
Weirton Steel Co., Div. of National Steel Corp., W. Va (g)
Wesbar Stamping Corp., Wis (c,g)
Wheeling Steel Corp., W.Va (g)
Whitehead Metal Products Co., Inc., NY (b,g)
Wisconsin Tool & Stamping Co., Ill (g)
Wright Metalcoaters, NJ (a,b,c,e,f,g)
Youngstown Kitchens Div., American Standard Co., Ohio (a,g)

Precoated Metals —Tin-Coated

Acme Stamping & Wire Forming Co., Pa (a,b,g)
American Silver Co., NY (a,b,e,f,g)
Anderson-Bolling Mfg. Co., Mich (g)
Association Spring Corp., Wallace Barnes Steel Div., Conn (g)
Bethlehem Steel Co., Pa (g)
Brasco Mfg. Co., Ill (g)
Caspers Tin Plate Co., Ill (g)
Columbia - Geneva Steel Div., U.S. Steel Corp., Calif (g)
Composite Industrial Metals, Inc., RI (a,b,c,d,e,f,g,j)
Conner Mfg. Co., Ky (g)
Granite City Steel Co., Ill (g)
Inland Steel Co., Ill (g)
Kaiser Steel Corp., Calif (g)
Koehler Mfg. Co., Mass (c,g)
Lundquist Tool & Mfg. Co., Inc., Mass (a,g)
Olean Electro Plating Co., NY
Philadelphia Steel & Wire Corp., Pa (g)
Republic Steel Corp., Ohio (g)—Ad pp 84-85
Riverside Foundry Co., Pa (c)
Smithers Tool & Machine Products, Inc., NY (g)
Solar Steel Corp., Ohio (g)
Somers Brass Co. Inc., Conn (b,f)
Stainless and Strip Div., Jones & Laughlin Steel Corp., Ohio (g)
Steel Protection & Chemical Co., Ind (a,b,c,f,g)
Sun Steel Co., Ill (g)
U. S. Steel Corp., Pa (g)
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (g)
Wabash Metal Products Co., Inc., Ind (g)
Weirton Steel Co., Div. of National Steel Corp., W.Va (g)
Wheeling Steel Corp., W.Va (g)
Wisconsin Tool & Stamping Co., Ill (g)
Wright Metalcoaters, NJ (a,b,c,e,f,g)
Youngstown Sheet & Tube Co., Ohio (g)

Pre-Impregnated Materials for Plastic Laminates

American Plastics Corp., NY (l)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Cincinnati Industries Inc., Ohio (k)
Coast Mfg. & Supply Co., Calif (l)
Cordo Chemical Corp., Conn (k,l,m)—Ad p 269
Cordo Molding Products, Inc., Conn (l)—Ad p 269
Eljay Corp., Md (k,l)
Emerson & Cuming, Inc., Mass (k,l,m)
Fabricon Products Div., Eagle-Picher Co., Mich (l)—Ad p 275
Firmaline Products of Crompton & Knowles, NJ (k,l)—Ad p 457
Flexfirm Products, Calif (k,l)
Flexible Tubing Corp., Conn (k)
Glastic Corp., Ohio (l)—Ad p 256
Haveg Industries Inc., Del (l)
Luminous Resins Inc., Ill (k)
Maloney, F.H. Co., Tex (l)
Micarta Div., Westinghouse Electric Corp., SC (l)
Minnesota Mining & Mfg. Co., Minn (l)
Minnesota Mining & Mfg. Co., Reinforced Plastics Div., Minn (l)—Ad pp 258-259
Modiglass Fibers, Inc., NJ (k,l)
Narmco Industries, Inc., Narmco Materials Div., Calif (l)
New England Laminates Co., Conn (l)
Panelyte Div., St. Regis Paper Co NJ (l)
Raybestos Div., Raybestos-Manhattan, Inc., Conn (l)
Riegel Paper Corp., NY (k,l)
Rogers Corp., Conn (l)
Russell Mfg. Co., Conn (l)
Spaulding Fibre Co., Inc., NY (l)
Standard Insulation Co., Plastics Div., NJ (l)
Sun Chemical Corp., Electro Technical Div., (k,l,m)
Swedlow, Inc., Calif (l)
U.S. Polymeric Chemicals, Inc., Conn (l,m)

Prepainted Metals

(see Organic Coatings)

Preplated Metals

(chromium, nickel)

Acme Stamping & Wire Forming Co., Pa (a,b,g)
Aluminum Co. of America, Pa (a)
American Nickelold Co., Ill (a,b,g,j)
American Silver Co., Inc., NY (b,f,g)
Apollo Metal Works, Ill (b,c,g,j)
Benjamin Electric Mfg. Co., Ill (g)
Chromalloy Corp., NY (g)
Enamelstrip Corp., Sub. of National Steel Corp., Pa (a,b,c,f,g,h,j)
Fromson Orban Co., Inc., NY (a)
Grand Sheet Metal Products Co., Consumer Products Div., Ill (a,b,c,e,f,g,h,j)
Grigoleit Co., Ill (a,g)
Hayden Wire Works, Inc., Mass (a,b,f,j)
Haydon Corp., NY (g)
Kassel Export Co., Inc., NJ (g)
Kroh Wagner, Ill (a,g)
Metal Trims, Inc., Miss (a)
Pittsburgh Steel Co., Pa (b,d,f,j)
Republic Steel Corp., Ohio (g)—Ad pp 84-85
Rigidized Metals Corp., NY (a,g)

Roebling's John A. Sons Div., Colorado Fuel & Iron Corp., NJ (g)
Sheldon, M. L. & Co., Inc., NY (f)
Sun Steel Co., Ill (g)
Sylvania Electric Products, Inc., Parts Div., Pa (a,b,c,f,g)
Thomas Strip Div., Pittsburgh Steel Co., Pa (b,f,j)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (g)
Worcester Wire Works Div., National-Standard Co., Mass (g)
Wright Metalcoaters, NJ (a,b,c,e,f,g)

Pressure Sensitive Tapes

(see tapes)

Protein Plastics

Adhesive Products Corp., NY (x)
American Hard Rubber Co., Div. of Amerace Corp., NJ (bb,cc,dd,ee)
American Plastics Corp., NY (bb,cc)
Borden Co., Borden Chemical Div., NY (p)
Chemical Process Co., Calif (x)
Heyden Newport Chemical Corp., American Plastics Corp. Div., NY (bb, cc,dd)
National Casein Sales, Ill (p)
Reichhold Chemicals, Inc., NY (p)

Quartz

(see Ceramics)

Rare Earth Metals

American Metallurgical Products Co., Pa
Davison Chemical Co., Div. of W. R. Grace & Co., Md
Foote Mineral Co., Pa
Heavy Minerals Co., Tenn
Lindsay Chemical Div., American Potash & Chemical Corp., Ill
Maywood Chemical Works, NJ
Michigan Chemical Corp., Rare Earths & Thorium Div., Mich
Molybdenum Corp. of America, Pa
Research Chemicals Div., Nuclear Corp. of America, Calif
Union Carbide Metals Co., Div. of Union Carbide Corp., NY
United Mineral & Chemical Corp., NY

Refractories, Aluminide

Commercialores, SC (aa)
Coors Porcelain Co., Colo (r,bb,ee)
Du-Co Ceramics Co., Pa (r,z,bb,ee)
Engineered Ceramics Mfg. Co., Ill (r,z,bb,ee)
Ironton Fire Brick Co., Ohio (r)
Louthan Mfg. Co. Div., Ferro Corp., Ohio (r,z,bb,cc,ee)

Refractories, Boride

Carborundum Co., Refractories Div., NJ (r,bb,ee)
Electro Refractories & Abrasives Corp., NY (aa)
Firth Sterling, Inc., Pa (r)
Norton Co., Mass (r,aa)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)

Refractories, Carbide

Carborundum Co., Refractories Div., NJ (r,u,aa,bb,ee)
Continental Coatings Corp., Ohio (aa)
Engineered Ceramics Mfg. Co., Ill (r,z,bb,ee)
Firth Sterling, Inc., Pa (r)
Norton Co., Mass (r,z,aa,bb,ee)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)

Refractories, Nitride

Carborundum Co., Refractories Div., NJ (r,bb,ee)
Norton Co., Mass (r,aa)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (s)

Refractories, Oxide

Beryllium Corp., Pa (r)—Ad p 157

Brush Beryllium Co., Ohio (r)—Ad p 171

Carborundum Co., Refractories Div., NJ (r,s,aa,bb,ee)
Continental Coatings Corp., Ohio (aa)
Corning Glass Works, NY (r,aa)
Du-Co Ceramics Co., Pa (r,z,aa,bb,ee)
Eagle-Picher Co., Ohio (s)
Electrical Refractories Co., Ohio (r,ee)
Electro Refractories & Abrasives Corp., NY (r)
Emerson & Cuming, Inc., Mass (u,cc)
Engineered Ceramics Mfg. Co., Ill (r, z,bb,ee)
General Refractories Co., Pa (r,aa)
Laboratory Equipment Corp., Mich (r, bb,ee)
Monsanto Chemical Co., Inorganic Chemicals Div., Mo (aa)
Morganite, Inc., NY (aa,bb,ee)
Norton Co., Mass (r,z,aa,bb,ee)
Refractory Specialties Co., Pa (r)
Research Chemicals Div., Nuclear Corp. of America, Calif (aa,bb)
Saxonburg Ceramics, Inc., Pa (r,bb, cc,ee)
Thermal Refractories Corp., NJ (r,z, bb,cc,ee)
Thompson, H.I. Fiber Glass Co., Calif (s)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
Zirconium Corp. of America, Ohio (r, u,z,aa,bb,ee)

Refractories, Silicide

Du-Co Ceramics Co., Pa (r,z,bb,ee)
Eagle-Picher Co., Ohio (s)
Electrical Refractories Co., Ohio (r)
Engineered Ceramics Mfg. Co., Ill (r,z,bb,ee)
General Ceramics Div., Indiana General Corp., NJ (r)
Ironton Fire Brick Co., Ohio (r)
Louthan Mfg. Co. Div., Ferro Corp., Ohio (r,z,bb,cc,ee)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
Western Gold & Platinum Co., Sub. of Wilbur B. Driver Co., Calif (r, z,bb,cc)

Reinforced Plastics

(see Laminates)

Rhenium

Chase Brass & Copper Co., Sub. of Kennecott Copper Corp., Conn (aa, bb,dd,ff)
Hardy, Charles, Inc., NY (aa)
Mallory, P.R. & Co., Inc., Ind (bb)
Nuclear Metals, Inc., Mass (w,bb)
University of Tennessee, Dept of Chemistry, Tenn (aa)

Rock Wool

(see Inorganic Fibers)

Rod

(see specific material)

Rods, Welding

(see Filler Metals)

Roll Formed Parts

Abalon Precision Mfg. Corp., NY (a, b,c,g)
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (g)

Alloy Products Corp., Wis (a,f,g,h)—Ad p 408

Aluminum Co. of America, Pa (a)
American Brass Co., Sub. of Anaconda Co., NY (b)
American Car & Foundry Div., ACF Industries, Inc., NY (a,e,g)
American Nickel Alloy Mfg. Corp., NY (f)
American Pipe & Construction Co., Northwest Div., Ore (g)
American Welding and Mfg. Co., Ohio (a,f,g,h)
Ampco Metal, Inc., Wis (b)
Arrow Metal Products Corp., NJ (a)
Beck, I. & Sons, Inc., NY (a,b,g)
Bethlehem Steel Co., Pa (g)
Biersach & Niedermeyer Co., Wis (a, b,c,g)
Binkley Co., Mo (g)
Brown Lipe Chapin Div., General Motors Corp., NY (a,g)
Brush Beryllium Co., Ohio (b)
Bunker Hill Co., Calif (d)
Burkhardt Steel Co., Colo (c,g)
Byers, A.M. Co., Pa (c)
Carbo Tool & Die Co., Ohio (c)
Chicago Screw Co., Div. of Standard Screw Co., Ill (a,b,c,f,g)
Coast Pro-Seal & Mfg. Co., Calif (a, b,f,g,h,j)
Craft Mfg. Co., Ill (f,g)
Crucible Steel Co. of America, Pa (g,h)
Crucible Steel Co. of America, Titanium & Vacuum Metal Products Div., Pa (h)
Dahlin, C.A. Co., Ill (a,b,e,f,g,h,j)
Day Co., Minn (a,g)
Division Lead Co., Ill (d)
Dow Chemical Co., Dow Metal Products Co. Div., Mich (e)
Dresser Mfg. Div., Dresser Industries, Inc., Pa (a,f,g,h)
Eaton Mfg. Co., Reliance Div., Ohio (g)
Edgewater Steel Co., Pa (g,h)
Ellwood City Iron & Wire Co., Pa (c)
Emerson-Sack-Warner Corp., Mass (a, b,f,g)
Enamel Products Co., Ohio (c)
Fabristeel Products, Inc., Mich (g)
Falstrom Co., NJ (a,b,e,g,h)
Fitzgibbons Boiler Co., Inc., NY (c)
Fletcher Enamel Co., W. Va (a,b,c,d,e, f,g)
Grigoleit Co., Ill (a,g)
Haydon Corp., NY (a,g)
Ideal Can Co., Mass (a,b,g)
Inland Steel Co., Ill (g)
Irwin-Sensenich Corp., Pa (g)
Jackson Steel Products, Inc., NY (a, b,f,g,j)
Kaiser Steel Corp., Calif (g)
Kelley Mfg. Co., Tex (a,b,g)
Kelsey-Hayes Co., Mich (g)
Kroh Wagner, Ill (a,b)
Leach & Garner Co., Industrial Div., Mass (b,f)
Le Tourneau, R.G., Inc., Tex (g)
Lock Joint Tube Co., Inc., Ind (g)
Magnesium Co. of America, Ind (a,e)
Magnesium Products of Milwaukee, Inc., Wis (a,e)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (a,b,c,e,f,g,h)
Manufacturers & Fabricators, Inc., Ohio (f,g)
McLanahan & Stone Corp., Pa (g)
Merrimac Brass, Mass (b,f)
Metal Forming Corp., Div. of Vanadium-Alloys Steel Co., Ind (a,b,f,g)
Midvale-Heppenstall Co., Pa (c,f,g)
Mirro Aluminum Co., Wis (a)
Morse, Fred W. Co., RI (a,b,c,g,j)
Morton Mfg. Co., Ill (a,g)
National Aluminum Co., Ohio (a,g)
National Metal Products Co., Pa (a, b,g,j)
National Screw & Mfg. Co., Ohio (b,g)
Nikoh Tube Co., Ill (g)
Nippert Electric Products Co., Ohio (b)
Parish Pressed Steel Div., Dana Corp., Pa (g)
Pfister Tubing Corp., NJ (a)
Posey Iron Works, Inc., Pa (g)
Pyramid Mouldings, Inc., Ill (a,b,c,g)
Regal Ware, Inc., Wis (a,b,g)
Revere Copper & Brass, Inc., Ill (a,b, c,f,g,j)
Reynolds Aluminum Supply Co., Ga (a)
Rockwell Engineering Co., Ill (a,b,c,g)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Rohr Aircraft Corp., Calif (a)
Roll Formed Products Co., Ohio (a, b,g,h)
Ryerson, Joseph T. & Son, Inc., Ill (a,g)
Sager Metal Strip Co., Ill (a,b,c,j)
Security Cos., Mich (a)
Security Sash & Screen Co., Mich (a)
Serrick Corp., John Lees Div., Ind (a,g)
Stainless and Strip Div., Jones & Laughlin Steel Corp., Ohio (g)
Standard Pressed Steel Co., Pa (b,g)
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa (g)
Stanwood Corp., Ill (g)
Sylvania Electric Products, Inc., Parts Div., Pa (b,f,g)
Textron Metals Co., Ohio (a)
Thompson Pipe & Steel Co., Colo (a,b, c,d,e,f,g)
U.S. Graphite Co., Div. of Wickes Corp., Mich (aa)
Vanadium-Alloys Steel Co., Pa (g)
Vulcan Mfg. Co., Ohio (a,b,c,f,g)
Wal-Mar Corp., Ill (a,b,c,e,g)
Werner, R.D. Co., Pa (a,b,g,j)
Western Automatic Machine Screw Co., Div. of Standard Screw Co., Ohio (a,b,c,f,g)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (a,b,c,e,f,g)
Wyatt Metal & Boiler Works, Inc., Tex (a,b,c,e,f,g)

Rubber, Natural

Adhesive Products Corp., NY (x)
American Hard Rubber Co., Div. of Amerace Corp., NY (bb,cc,dd)
American Rubber Products Corp., Ind (u,bb,cc,dd,ee)
Atlas Mineral Products Co., Pa (cc)
Auburn Rubber Co., Inc., Ind (cc)
Automotive Rubber Co., Inc., Mich (cc, dd)
Belko Corp., Md (y)
Bond International, Inc., Mich (y,ee)
Broadway Rubber Corp., Ky (u,cc)
Brown Rubber Co., Inc., Ind (u)
Capac Mfg. Corp., Mich (y,cc)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chicago-Allis Mfg. Corp., Ill (p)
Colonial Rubber Co., Div. of U.S. Stoneware Co., Ohio (y)
Continental Rubber Works, Pa (bb,cc, dd,ee)
Coyne & Paddock, Inc., NY (cc)
Dayton Rubber Co., Ohio (u,y,bb,cc,dd, ee)
Douglas & Sturgess, Calif (x,y)
Johns-Manville Corp., Dutch Brand Div., Ill (u,y,cc,dd)
Faultless Rubber Co., Ohio (u,y,bb,ee)
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass (s,u,y,cc,ee)
Flexible Tubing Corp., Conn (ee)
Foam Products, Inc., Pa (u)
Foamade Industries, Mich (u)
Garlock Packing Co., NY (y,bb,cc,dd, ee)
Geauga Industries Co., Ohio (y,bb,dd)
Goodrich, B.F. Chemical Co., Sponge Products Div., Conn (u)
Goshen Rubber Co., Inc., Ind (y)
Hardman, H.V. Co., Inc., NJ (x)
Hayes Adhesive Co., Inc., Mo (y)
Hewitt-Robins, Inc., Conn (cc,ee)
Home Rubber Co., NJ (y,bb,cc,dd,ee)
Johns-Manville Corp., NY (cc)
Luzerne Rubber Co., NJ (bb,cc,dd,ee)
Maloney, F.H. Co., Tex (y)
Martin Rubber Co., Inc., NJ (y,dd,eee)
Mid-States Rubber Products, Inc., Ind (y)
Morningstar-Paisley, Inc., NY (y)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (u,x,y)
Paeco Rubber Co., Inc., Ohio (y)
Parker Seal Co., Div. of Parker-Hannifin Corp., Calif (u)
Parker, Stearns & Co., Inc., NY (y, bb,cc,dd,ee)
Pawling Rubber Corp., NY (bb,dd,ee)
Polymer Chemical Co., Ohio (x,y)
Rand Rubber Co., NY (p,t,cc)
Raybestos-Manhattan, Inc., NJ (bb, cc,dd)
Raybestos-Manhattan, Inc., Plastic Products Div., Pa (x)
Republic Rubber Div., Lee Rubber & Tire Corp., Ohio (p,y,bb,cc,dd,ee)
Roberts Toledo Rubber Co., Ohio (ee)
Rogers Corp., Conn (y,cc,dd)
Roth Rubber Co., Ill (y,cc)
Rubatex Div., Great American Industries, Inc., Va (u)
Rubber Corp. of America, NY (u)
Russell Mfg. Co., Conn (s)
Sheller Mfg. Corp., Mich (u)
Snyder, M.L. & Son, Inc., Pa (ee)
Standard Products Co., Mich (y)
Stockwell Rubber Co., Inc., Pa (u,y, bb,cc,dd)
Technical Specialties Co., NY (dd)
Toyad Corp., Pa (t,u)
Trostel, Albert Packing, Ltd., Wis (y)
U.S. Rubber Co., Kem-Blo Dept., Conn (u)—Ad p 250
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (p,y,cc)
Vulcanized Rubber & Plastics Co., Pa (y)
Western Felt Works, Ill (y,cc,dd,ee)
Williams-Bowman Rubber Co., Ill (y,bb,cc,dd,ee)

Rubber, Synthetic

(see specific material)

Sand Castings

(see Castings)

Sandwich Materials

(key letters refer to core materials)
Aerojet-General Corp., Structural Materials Div., Calif (a,g)
Allegheny Ludlum Steel Corp., Pa (g)
Almco Steel Products Corp., Ind (g)
Aluminum Co. of America, Pa (a)
Antara Chemicals, Div. of General Aniline & Film Corp., NY (c)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Artmor Plastics Corp., Md (a,k,l,m)
Bar-Ray Products, NY (d)
Bridgeport Brass Co., Conn (g)
Brunswick Corp., Defense Products Div., Mich (a,l)
Busch, J.C. Co., NY (a,c)
Cincinnati Industries Inc., Ohio (k)
Composite Industrial Metals, Inc., RI (a,b,c,d,e,f,g,h,j)
Continental Rubber Works, Pa (m)
Dow Chemical Corp., Plastics Div., Mich (k)
Douglas Aircraft Co., Inc., Aircomb Div., Calif (l)
Dumont Corp., Calif (a,k,m)
General Findings & Supply Co., Industrial Div., Mass (b,f)
General Tire & Rubber Co., Ind (l)
Glo-Brite Products, Inc., Ill (l)
H & R Industries, Pa (k,l,m)
Hardy Mfg. Corp., Ind (k)
Haskelite Mfg. Corp., Mich (k,l,m)
Hawkeye Rubber Mfg. Co., Iowa (g,m)
Hexcel Products, Inc., Calif (a,g)
Kassel Export Co., Inc., NJ (g)
Leach & Garner Co., Industrial Div., Mass (b,f)
Lukens Steel Co., Pa (a,b,e,f,g,h)
Luminous Resins, Inc., Ill (k)
Lunn Laminates, Inc., NY (l)
Mechanical Rubber Products Co., NY (l)
Minnesota Mining & Mfg. Co., Minn (l)
Mobay Chemical Co., Pa (k)
National Moldite Co., NJ (c)
National Vulcanized Fibre Co., Del (l)
Northwest Plastics Industries, Inc., Wash (l)
Nuclear Metals, Inc., Mass (a,b,c,e,f, g,h)
Permacel, NJ (l)
Presswork, Inc., Mich (b,d)
Replac Corp., Ohio (k,l,m)
Riegel Paper Corp., NY (k,l)
Rogers Corp., Conn (l,m)
Rohr Aircraft Corp., Calif (f,g)
Russell Mfg. Co., Conn (b)
Russell Reinforced Plastics Corp., NY (l)
Solar Aircraft Co., Calif (g,h)
Standard Insulation Co., NJ (l)
Standard Metals Corp., Mass (c,f)
Superior Steel Div., Copperweld Steel Co., Pa (g)
Swedlow, Inc., Calif (a,f,g,h)
Thermoid Div., H.K. Porter Co., Pa (l)
Thompson, H. I. Fiber Glass Co., Calif (g)
Toyad Corp., Pa (k)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
U.S. Polymeric Chemicals, Inc., Conn (l)
West Haven Foundry Co., Conn (a,b)
Wittman, Lawrence & Co., NY (k,l)
Zenith Plastics Co., Calif (l)

Screw Machine Parts

Abalon Precision Mfg. Corp., NY (a, b,c,g)
Abbott Products, Inc., NY (a,b,c,d,e, f,g,h,j)
Advance Screw Products Co., Inc., Wis (a,b,c,g)
Affiliated Screw Products Co., Ill (a, b,c,d,e,f,g,h,j)
Albany Products Co., Inc., Conn. (b,f)
Allied Machine Products Co., Mich (a,b,g)
Allied Metal Products Co., Mass (a, b,c,g)
Allied Products Corp., Mich (g)
Allmetal Screw Products Co., Inc., NY (f,g,h)
Aluminum Co. of America, Pa (a)
American Electrical Products Co., Ohio (a,b,f,g)
American Fabricated Products Co., Ind (a,b,f,g)
American Sanitary Mfg. Co., Ill (b)
American Screw Products Co., Mich (a,b,g)
Ampco Metal, Inc., Wis (b)
Anti-Corrosive Metal Products Co., Inc., NY (g)
Approved Mfg. Co., Inc., Mich (b,g)
Argosy Products, Inc., Ohio (a,b,g)
Ashby Mfg. Co., Mo (b,f,g)
Atkins Saw Div., Borg-Warner Corp., Ind (g)
Auburn Spark Plug Co., Inc., NY (a, b,c,d,f,g,h)
Auel Industries, Pa (a,b,g)
Autel Electronics Co., Precision Machine & Welding Div., NJ (a,b,c,e, g,h)
Automatic Metal Products Corp., Mich (b,f,g,h)
Babson Dow Mfg. Co., Mass (a,b,c, f,g)
Balas Collet Mfg. Co., Ohio (a,b,f,g)
Baldwin Mfg. Co., Conn (a,b,c,d,f, g,h,j)
Barton Products Corp., Wis (a,b,c,e, f,g)
Bayley Products, Inc., Mich (a,b,g)
Beacon Metal Mfg. Co., NY (a,b,c,e, f,g,h,j)
Beck Products Corp., Mich (a,b,f,g)
Bethandale Corp., Ohio (a,b,f,g)
Bethlehem Steel Co., Pa (g)
Bickford, F.H. Co., Ohio (a,b,g)
Biddle Screw Products Co., Ind (a,b, c,d,e,f,g,h)
Blacher Bros., Inc., RI (a,b,g)
Boehm Screw Products Co., Mich (a, b,f,g)
Boots Aircraft Nut Corp., Conn (a, b,f,g)
Brown Corp., NY (g)
Buchmann Spark Wheel Corp., NY (a, b,c,e,f,g)
Buckeye Brass & Mfg. Co., Ohio (b)
Burgess-Norton Mfg. Co., Ill (c)
C & G Screw Machine Products Co., Ind (a,b,g)
Carleton Screw Products Co., Minn (a, b,g)
Cartwright, R. Tube Products Co., Mich (a,b,g)
Central Screw Products Co., Mich (a, b,f,g)
Chapman Machine Co., Inc., Conn (a, b,f,g)
Chardon Metal Products Co., Ohio (a, b,f,g)
Chicago Screw Co., Div. of Standard Screw Co., Ill (a,b,c,f,g)
Clendenin Bros., Inc., Md (b)
Cleveland Cap Screw Co., Ohio (a,b, f,g,h)
Collis Co., Iowa (a,b,f,g)
Columbus Dental Mfg. Co., Ohio (a, b,c,g)
Columbus Jack Corp., Ohio (a,c,g)
Columbus Production Mfg. Co., Ohio (a,b,g)
Comerford Mfg. Co., Inc., Conn (a,b, c,e,f,g,h,j)
Condamatic Co., Inc., Mich (a,g,h)
Conn Perry Mfg. Co., Mich (b,g)
Connecticut Mfg. Co., Conn (b,f,g)
Control Parts Corp., NY (a,b,c,d,e,f, g,h,j)
Couch-Uthe Co., Ohio (b,f,g)
Curtis Products Co., Conn (a,b,c,f,g)
Curtis Screw Co., Inc., NY (a,b,f,g)
Davis & Hemphill, Md (a,b,c)
Dawlen Corp., Mich (a,b,c,f)
Decatur Automatic Co., Ill (a,b,f,g)
Deerfield Mfg. Co., Ohio (a,b,f,g)
Defiance Screw Machine Products Div., Serrick Corp., Ohio (g)
Delo Screw Products Co., Ohio (a, b,f,g)
Delron Co., Inc., Calif (a,g)
Dependable Automatic Screw Co., Conn (a,b,c,d,e,f,g,h,j)
Dixon Corp., RI (k)
Drexel Screw Products Co., Ill (a,b, c,d,f,g,k)
Duffin Mfg. Co., Ohio (a,b,g,h)
Duro Screw & Mfg. Co., NJ (a,b, f,g,h)
Eastern Machine & Screw Corp., Conn (a,g)
Eby, Hugh H. Co., Pa (a,b,f)
Economy Machine Products Co., Ill (a,b,f,g)
Electric Auto-Lite Co., Ohio (a,b,c,g)
Electric Materials Co., Pa (b)
Electronic Parts Mfg. Co., Inc., NJ (c,f,g)
Elsby, J.S., Inc., Wis (a,b,f,g)
Enoch Mfg. Co., Ore (a,b,c,e,g,j)
Essential Bar Products Co., Mich (a, b,f,g)
Eureka Electric Products Co., Pa (a,b)
Everard Tap & Die Corp., NY (a,b,c, f,g)
Fairchild Screw Products, Inc., Conn (a,b,f,g)
Falls Machine Co., Ohio (a,b,g)
Federal Screw Works, Mich (a,b,f,g)
Femco Mfg. Co., Inc., Mich (g)
Fischer Special Mfg. Co., Ohio (a,b)
Fordsell Machine Products Co., Mich (a,b,f,g)
Frisby, R.J. Mfg. Co., Ill (a,b,g)
G & G Mfg. Co., Ill (a,b,f,g)
G & Z Automatic Products Co., Mich (a,b,g)
Gantner Screw Products Co., Inc., Ohio (a,b,f,g)

General Engineering Works, Ill (a,b,f,g)
General Findings & Supply Co., Industrial Div., Mass (a,b,c,f,g)
General Screw Products Corp., NY (a,b,f,g)
Grass, M.J. Machine Products Co., NY (a,b,f,g)
Greer Stop Nut Co., Ill (a,b,c,e,f,g,h,j)
Gregg Metal Products Inc., Wis (a,b,f,g)
Gross Willard N., Inc., NJ (a,b,f,g)
H & H Screw Products, Inc., NY (a,b,f,g,h)
H & H Screw Products Mfg. Co., RI (a,b,f,g)
H & K Machine Service Co., Inc., Mo (a,b,g)
Haber, Ill (a,b,c,f)
Hack, J.H. Mfg. Co., Mich (a,b,f,g)
Hardy Mfg. Corp., Ind (a,b,g)
Harvey Aluminum, Calif (a,g)
Harvin & Co., NJ (a,b,f,g)
Harwood Screw Products, Inc., Ohio (a,b,g)
Held, O.P., Inc., NY (a,b,c,g)
Heller, A.B. Screw Products, Inc., Mich (a,b,g)
Henefelt Precision Products, Ohio (a,b,f,g)
Hercules Fastener Co., Ill (a,c,f,g,j)
Herker Screw Products, Inc., Wis (a,b,g)
Herman Machine & Tool Co., Ohio (a,b,f,g)
Hershey Metal Products, Inc., Conn (a,b,f,g,h)
Holt Products Co., Mich (a,g)
Hoofer Mfg. Co., Ill (a,c)
Hoyt, Charles D. Co., Inc., Ind (a,b,f,g)
Huck Mfg. Co., Mich (a)
Hudson Screw Machine Products Co., Ill (a,b,c,e,f,g,h,j)
Hunt Screw & Mfg. Co., Ill (a,b,f,g,h)
Huron Automatic Screw Co., Mich (a,b,g)
Hy-Level Screw Products Co., Ohio (a,b,g)
Ideal Metal Products Co., Ill (a,b,f,g)
Imsande Screw Products Co., Ohio (a,b)
Industrial Precision Products, Ill (a,b,c)
Inland Mfg. Co., Neb (a,b,c,d,e,f,g,h,j)
Instrument Parts Corp., NY (a,b,c,f,g)
Instrument Specialties Co., Inc., NJ (b)
Jaques Co., Mass (a,b,e,f,g,h)
Jolens Metal Products Co., NJ (a,b,f,g)
Jordan Machine Products, Inc., Mich (a,b,f,g)
Kay-Bee Machine Products Co., Wis (a,b,g)
Kennedy Automatic Products, Inc., Mich (a,b,g)
Kenosha Automatic Products Co., Wis (a,b,g)
Kerr-Lakeside Industries, Inc., Ohio (a,b,f,g)
Kewaunee Engineering Corp., Wis (c)
Klincher Locknut Corp., Ind (a,b,c,f,g)
Koehler Mfg. Co., Mass (c)
Kohn Engineering Corp., Mich (a,b,c,f,g,h)
Kramer, C.P. Co., Ill (a,f,g)
Lake Mfg. Corp., Conn (a,b,g)
Lamson Products Co., Wash (a,b,d,e,f,g,j)
Lattner Bros. Machining Co., Mich (a,b,f,g)
Latwaitis, Ernest A., NY (a,b,f,g)
Lawrenceville Screw Co., Pa (a,b,f,g)
Lincoln Machine Parts Corp., NY (a,b,f,g,h)
Lincoln Mfg. Co., Inc., Ill (a,b,f,g)
Linden & Co., Inc., RI (a,b,c,g)
Livingston-Tyler Products, Ohio (a,b,e,g)
Locke Machine Co., Ohio (a,b,e,f,g)
Loeffler, J.M. Machine Co., Pa (a,b,c)
Lorain Automatic Screw Machine Co., Inc., Ohio (a,b,g)
Lubenow, Arthur Co., Wis (a,b,f,g)
Lundberg Screw Products Co., Mich (a,b,g)
Lyndon Machine Products Co., Inc., Mich (a,b,g)
M & S Mfg. Co., Mich (a,b,g)
Machine Products Corp., Ohio (a,b,c,d,e,f,g,h,j)
Machinery Products Co. of Lancaster, Pa (a,b,f,g)
Machinery Products Corp., Ill (a,b,f,g)
Mac-It Parts Co., Pa (b,f,g)
Main Screw Machine Products, Inc., Conn (a,b,g)
Mantel Screw Products Co., Wis (a,b,f,g,h)
Marquette Metal Products Co., Ohio (a,b,f,g)
Masco Screw Products Co., Mich (a,b,f,g)
Massachusetts Screw Mfg. Co., Mass (a,b,f,g)
Maynard Mfg. Co., Mich (a,b,f,g,h)
McKinney Mfg. Co., Pa (a,b,e,f,g)
McLanahan & Stone Corp., Pa (c,g)
McMahon Bros. Machine Works, Inc., Ill (a,b,f,g,h)
Meaden Screw Products Co., Ill (a,b,f,g)
Measuregraph Co., Mo (a,b,f,g,h)
Mechanical Art Works, Inc., NJ (a,b,f,g)
Meier Screw Products & Mfg. Co., Mich (a,b,c,e,f,g)
Merit Screw Machine Products Co., Ill (a,b,f,g,h)
Merit Specialties Co., Inc., Mo (a,b,e,f,g)
Merz Machine & Tool Works, Ind (a,b,g)
Micro Products Corp., Mo (a,g)
Mid-West Screw Products Co., Mo (a,b,c,g)
Midwest Screw Products, Inc., Ohio (a,b,f,g,h)
Milford Automatics, Inc., Conn (a,b,g)
Milled Screw Products, Co., Ill (a,b,f,g)
Millers' Brass Fitting Co., Inc., NY (a,b,f,g)
Milwaukee Machine Products Co., Wis (a,b,g)
Milwaukee Stamping Co., Wis (a,g)
Mitchell & Scott Machine Co., Inc., Ind (a,b,f,g)
Modern Screw Products Co., Mo (b,f,g)
Monarch Tool & Mfg. Co., Ky (g)
Moody Machine Products Co., Inc., RI (a,b,c,f,g)
Moore, George W., Inc., Mass (a,b,g)
Mueller Brass Co., Mich (a,b,f)—Ad p 455
Mueller Machine Products Inc., Wis (a,b,c,d,e,f,g,j)
Napoleon Products Co., Ohio (a,g)
National Acme Co., Ohio (a,b,f,g)
National Lead Co., NY (a)
National Screw & Mfg. Co., Ohio (b,f,g)
New Britain Machine Co., Conn (a,b,g)
New Haven Screw Machine Products, Inc., Conn (a,b,f,g,h,j)
Newtown Mfg. Co., Conn (a,b,f,g,h)
Nicoud Mfg. Co., Ill (a,b,f,g)
Noera Mfg. Co., Conn (a,b,g)
Nolte Screw Machine Products Co., Ohio (a,b,c,f,g)
Northwest Automatic Products Corp., Minn (a,b,f,g)
Nutmeg Screw Machine Products Co., Conn (a,b,f,g)
Nylok Corp., NJ (a,b,c,e,g,h)
Ohio Metal Products Co., Ohio (a,b,f,g,h)
Ohio Screw Products, Inc., Ohio (a,b,f,g)
Olderman Mfg. Corp., Conn (a,b)
Olson Mfg. Co., Mass (a,b,f,g)
Ostby & Barton Co., Flightex Fabrics, Inc., RI (a,b,f,g)
Ottawa Steel Products, Inc., Mich (g)
Owen Mfg., Inc., Ill (a,b,f,g)
Pabst Engineering Equipment Co., Inc., NJ (a,b,c,e,f,g,h,j)
Pacific Screw Products Co., Calif (a,b,f,g)
Pan-American Metal Products Co., Inc., Fla (a,b,f,g)
Parker & Harper Mfg. Co., Mass (a,b,f,g)
Peck Spring Co., Conn (a,b,c,f,g)
Peerless Automatic Machine Co., Ohio (a,b,c,g)
Peerless Industries, Inc., Mich (a,b,g)
Peerless Products Industries, Ill (a,b,g)
Perry Fay Co., Ohio (a,b,g)
Philadelphia Enameling Works Inc., Pa (a,b,g)
Phillips, F.C., Inc., Mass (b,f,g)
Phillips Bros. Screw Products Co., Mich (b,f,g,h)
Piper Tool Co., Inc., Mich (g)
Pohlman, R.L. Co., Mo (a,b,g)
Polyphase Machine Co., NY (a,b,f,g,h)
Precision Machine Co., Ind (a,b,g)
Precision Piece Parts, Inc., Ind (g)
Precision Screw Products Co., Inc., Calif (a,b,f,g)
Progressive Service Co., Mo (a,b,e,f,g)
Racine Screw Co., Wis (a,b,f,g)
Rainier Metal Products Co., Ill (a,b,g)
Rasco-Veeder Co., Ill (a,b,f,g)
Ravenswood Machine Corp., Ill (a,b,f,g)
Red Devil Mfg. Co., Ill (a,b,c,d,e,f,g,h,j)
Redmer Air Devices, Ala (a,b,c,f,g)
Reliable Screw Machine Products, Ill (a,b,f,g,h)
Remler Co., Ltd., Calif (a,b,f,g)
Rex Products Co., Ohio (a,b,f,g)
Richmond Mfg. Co., Tex (a,b,f,g)
Rockwell Engineering Co., Ill (a,b,c,g)
Rosan Inc., Calif (a,g)
S & S Mfg. Co., NJ (a,b,c,e,f,g,h)
Sargent & Greenleaf, Inc., NY (a,b,g)
Scovill Mfg. Co., Mill Products Div., Conn (a,b)
Seltzer, George H. & Co., Pa (g)
Sheller Mfg. Corp., Mich (g)
Sinclair Co., Mass (a,b,g)
Skookum Co., Inc., Ore (g)
Spencer Nahm Co., Calif (a,b,f,g)
Spencer's Sons, I.S., Inc., Conn (a,b,g)
Standard Pressed Steel Co., Pa (a,b,c,e,f,g,h)
Standard Screw Products Co., Calif (a,b,g)
Star Heel Plate Co., Inc., NJ (g)
Steel Heddle Mfg. Co., Pa (a,b,c,e,f,g,h,j)
Steel Industries, Inc., Ind (a,b,g)
Steinen, Wm. Mfg. Co., NJ (a,b,c,f,g,h)
Thompson-Bremer & Co., Ill (a,b,c,f,g,h)
Thompson Products, Inc., Ohio (h)
Titan Metal Mfg. Co., Pa (a,b)
Tompkins Products, Mich (a,b,c,d,f,g,j)
Trigon Specialties Corp., Ind (a,b,c,d,e,f,g,h,j)
Ullmann, Inc., Wis (a,b,c,e,f,g,h)
Union Screw & Mfg. Co., Pa (a,b,g)
United Screw & Bolt Corp., Ill (a,b,g)
United Shoe Machinery Corp., Mass (a,b,c,f,g)
Unity Machine & Tool Corp., Pa (a,g)
Vanamatic Co., Ohio (a,b,g)
Wagner Specialty Co., Wis (a,b,c,g,j)
Wall, P. Mfg. Co., Pa (a,b,c,g)
Waldman, Joseph & Sons, Epoxy Products Div., NJ (a,b,c,f,g)
Walrod Machine Products, Ore (a,b,g)
Ward, H.H. Co., Pa (a,b,c,f,g,j)
Waterman Industries, Inc., Calif (a,b)
Weatherhead Co., Ind (a,b,c,d,e,f,g,h,j)
Weber-Knapp Co., NY (a)
Wedler Bros., Inc., Ohio (a,b,f,g)
Western Automatic Machine Screw Co., Div. of Standard Screw Co., Ohio (a,b,c,f,g)
Western Machine Co., Wis (a,b,c,f,g,j)
Wirth, Carl & Son, Inc., NY (a,b,c,d,e,f,g,h,j)
Worth Co., Wis (a,b,c,g)
Wright, Albert Screw Machine Products, Calif (a,b,f,g)
Wuest Bros., Inc., Ky (a,b,c,f,g)
Zeller Corp., Ohio (g)

Selenium

American Metal Climax, Inc., NY (aa)
American Nickel Alloy Mfg. Corp., NY (aa)
American Smelting & Refining Co., NY (q,aa)
Anaconda Co., NY (aa)
Belmont Smelting & Refining Works, Inc., NY (aa)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Cerro de Pasco Sales Corp., NY (aa)—Ad p 178
Federated Metals Div., American Smelting & Refining Co., NY (aa)
Hardy, Charles, Inc., NY (aa)
Hommel, O. Co., Pa (aa)
Kawecki Chemical Co., NY (aa)
McGean Chemical Co., Ohio (aa)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Phelps Dodge Refining Corp., NY (aa)

Sheet

(see specific material)

Sheet Formed Plastics Parts

(see Moldings, Sheet)

Sherardized Coatings

(see Diffusion Coatings)

Silicides

(see Refractories)

Silicon

American Nickel Alloy Mfg. Corp., NY (w,aa)
Belmont Smelting & Refining Works, Inc., NY (aa)
du Pont de Nemours, E. I. & Co., Inc., Del (w)
Foote Mineral Co., Pa (q)
Hardy, Charles, Inc., NY (aa)
Lavin, R. & Sons, Inc., Ill (w)
Monsanto Chemical Co., Inorganic Chemicals Div., Mo (q,w,bb)
National Electric Div., H.K. Porter Co., Pa (ff)
National-Standard Co., Mich (ff)—Ad p 421
National-U.S. Radiator Corp., Plastic Metals Div., NY (aa)
Sylvania Electric Products, Inc., Chemical & Metallurgical Div., Pa (w,bb,ee)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
Utica General Jobbing Foundry, Inc., NY (aa)
Vanadium Corp. of America, NY (w)

Silicon Bronze

(see Copper)

Silicone Plastics

Adhesive Products Corp., NY (x)
Alpha Wire Corp., NY (ee)
Belko Corp., Md (y)
Bisonite Co., Inc., NY (y)
Colonial Kolonite Co., Ill (bb,cc,ee)
Comco Plastics, Inc., NY (bb,cc,dd,ee)
Continental-Diamond Fibre Corp., Del (bb,cc,dd,ee)
Cordo Chemical Corp., Conn (y)
Cordo Molding Products, Inc., Conn (y)
Curbell, Inc., NY (bb,cc,dd,ee)
Dodge Fibers Corp., NY (s)
Dow Corning Corp., Mich (p,u,x,y)
Dyna-Therm Chemical Corp., Calif (p)
Electrofilm, Inc., Calif (t)
Emerson & Cuming, Inc., Mass (u)
Flexible Tubing Corp., Conn (ee)
Formica Corp., Sub. of American Cyanamid Co., Ohio (cc,ee)
General Electric Co., Laminated Products Dept., Ohio (cc)
General Electric Co., Silicone Products Dept., NY (p,u,x,y)
General Gasket, Inc., Conn (cc)
Glass Reinforced Plastics Corp., Ohio (bb,ee)
Hall, C.P. Co., Ohio (p)
Hewitt-Robins, Inc., Conn (u,cc,ee)
Insulation Mfrs. Corp., Ill (p,y,bb,cc,dd,ee)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Kurz Kasch, Inc., Ohio (y)
Maloney, F.H. Co., Tex (y)
Mesa Plastics Co., Calif (p,y,bb,cc)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (bb,cc)
Narmco Industries, Inc., Narmco Materials Div., Calif (x)
National Gasket & Washer Mfg. Co., Inc. NY (bb,cc,dd,ee)
National Vulcanized Fibre Co., Del (bb,cc,dd,ee)
Panelyte Div., St. Regis Paper Co., NJ (x,bb,cc,dd,ee)
Parker, Stearns & Co., Inc., NY (bb,cc,dd,ee)
Pawling Rubber Corp., NY (bb,dd,ee)
Philrus Products Co., NJ (bb,cc,dd,ee)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (x)
Prince Rubber & Plastics Co., Inc., NY (bb,cc,ee)
Raybestos-Manhattan, Inc., NJ (bb,cc,dd)
Raybestos-Manhattan, Inc., Plastic Products Div., Pa (x)
Rogers Corp., Conn (u,y,bb,cc,dd)
Roth Rubber Co., Ill (cc)
Staver Co., Inc., NY (cc,dd)
Swedlow Inc., Calif (cc)
Synthane Corp., Pa (bb,cc,dd,ee)
Taylor Fibre Co., Pa (bb,cc,dd,ee)
Toyad Corp., Pa (u)
Union Carbide Corp., Silicones Div., NY (p,t,x,y)—Ad p 277
U.S. Polymeric Chemicals, Inc., Conn (s)
Varflex Corp., NY (ee)
Western Felt Works, Ill (cc)
William Brand-Rex Div., American Enka Corp., Mass (ee)

Silicone Rubber

Adhesive Products Corp., NY (x)
Alpha Wire Corp., NY (ee)
Armstrong Cork Co., Pa (bb,cc,dd)
Belko Corp., Md (y)
Bond International, Inc., Mich (y,ee)
Capac Mfg. Corp., Mich (y)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chicago-Allis Mfg. Corp., Ill (p)
Coast Pro-Seal & Mfg. Co., Calif (y)
Colonial Rubber Co., Div. of U.S. Stoneware Co., Ohio (y)—Ad p 441
Connecticut Hard Rubber Co., Conn (s,u,y,bb,cc,dd)
Continental Rubber Works, Pa (bb,cc,dd,ee)
Continental-Diamond Fibre Corp., Del (cc,dd)
Dayton Rubber Co., Ohio (y,bb,cc,dd,ee)
Delta Plastics Co., NJ (bb,cc,dd)
Dodge Fibers Corp., NY (s)
Dow Corning Corp., Mich (p,u,x,y)
Dyna-Therm Chemical Corp., Calif (p)
Flexible Tubing Corp., Conn (ee)
Garlock Packing Co., NY (y,bb,cc,dd,ee)
General Electric Co., Chemical & Metallurgical Div., Ill (cc,dd,ee)
General Electric Co., Plastics Dept., Ill (p,y,bb,cc,dd,ee)
General Electric Co., Silicone Products Dept., NY (p,u,y)
Goshen Rubber Co., Inc., Ind (y)—Ad p 438
Haveg Industries, Inc., Del (bb,cc,ee)—Ad pp 425-426
Hewitt-Robins, Inc., Conn (cc,ee)
Insulation Mfrs. Corp., Ill (cc)
Maloney, F.H. Co., Tex (y)
Mechanical Rubber Products Co., NY (t,u,bb,cc,dd)
Micarta Div., Westinghouse Electric Corp., SC (cc)
Mid-States Rubber Products, Inc., Ind (y)
Minnesota Rubber Co., Minn (ee)
Moxness Products, Inc., Wis (bb,cc,dd,ee)—Ad p 460
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
Paeco Rubber Co., Inc., Ohio (y, dd, ee)
Parker Seal Co., Div. of Parker-Hannifin Corp., Calif (u)
Pawling Rubber Corp., NY (bb,dd,ee)
Permacel, NJ (t,u,bb,cc)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (t)
Prince Rubber & Plastics Co., Inc., NY (bb,cc,ee)
Raybestos-Manhattan, Inc., NJ (bb,cc,dd)
Raybestos-Manhattan, Inc., Plastic Products Div., Pa (x)
Rogers Corp., Conn (u,y,cc,dd)
Roth Rubber Co., Ill (cc)
Stockwell Rubber Co., Inc., Pa (u,y,bb,cc,dd)
Swedlow, Inc., Calif (cc)
Taunton Div., Haveg Industries Inc., Mass (u,bb,cc,dd,ee)
Toyad Corp., Pa (u)—Ad p 260
Trostel, Albert Packing, Ltd., Wis (y)
Union Carbide Corp., Silicones Div., NY (p,y,cc,dd)—Ad p 277
U.S. Polymeric Chemicals, Inc., Conn (s)
U.S. Stoneware Co., Ohio (y)
Varflex Corp., NY (ee)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (p,y,cc)
Western Felt Works, Ill (y,cc,dd,ee)
William Brand-Rex Div., American Enka Corp., Mass (ee)
Williams-Bowman Rubber Co., Ill (y,bb,cc,dd,ee)

Silver and Its Alloys

Alloy Metal Powders, Inc., Iowa (aa)
Alpha Metals Inc., NJ (n,o,q,bb,cc,dd)
American Metal Climax, Inc., NY (w,aa)
American Platinum & Silver Div., Engelhard Industries, Inc., NY (n,o,q,v,w,z,aa,bb,cc,dd,ff)—Ad p 159
American Products Corp., Ill (dd,ff)
American Silver Co., NY (v,dd,ee,ff)
American Smelting & Refining Co., NY (n,o,q,bb,ee)
Anaconda Co., NY (o)
Baker & Co., Inc., NJ (n,o,v,w,z,aa,bb,cc,dd)
Belmont Smelting & Refining Works, Inc., NY (o,dd,ff)
Bunker Hill Co., Sales & Fabrication Div., Calif (o)
Cerro de Pasco Sales Corp., NY (o,w)
Composite Industrial Metals, Inc., RI (p)
Designers Metal Corp., Ill (cc)
Division Lead Co., Ill (ff)
Eastern Smelting & Refining Corp., Mass (n,o,v,w,aa,bb,cc,dd,ee,ff)
Eynon-Dakin Co., Mich (ee)
Federated Metals Div., American Smelting & Refining Co., NY (n)
Fox Products Co., Pa (n)
Fulton Gold Refiners Corp., NY (n,o,q,v,w,aa,bb,cc,dd)
Gibson Electric Co., Pa (aa,bb,dd,ff)—Ad p 466
Goldsmith Bros. Div., National Lead Co., Ill (n,o,v,w,z,aa,bb,cc,dd,ff)
Handy & Harman, NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)—Ad p 152
Hanovia Chemical & Mfg. Co., NJ (aa)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (ff)
Hommel, O. Co., Pa
Horton-Angell Co., Mass (n,o,bb,cc,dd,ee,ff)
Hudsar, Inc., NJ (w)
Leach & Garner Co., Industrial Div., Mass (n,o,q,v,z,bb,cc,dd)
Lucas-Milhaupt Engineering Co., Wis (dd,ff)
Makepeace, D.E. Div., Engelhard Industries Inc., Mass (n,o,v,z,aa,bb,dd,ee,ff)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Metals Disintegrating Co., Inc., NJ (aa)
Metz Refining Co., NJ (n,o,q,z,aa,bb,cc,dd,ee)
Minimax Co., Ill (aa)
Nesor Alloy Products Co., NJ (dd,ff)
Ney, J.M. Co., Industrial Div., Conn (y,z,bb,cc,dd,ff)
Norwalk Powdered Metals, Inc., Conn (aa)
Peerless Roll Leaf Co., Div. of Howe Sound Co., NJ (v,dd)
Reade Mfg. Co., Inc., NJ (aa)
Republic Metals Co., Inc., NY (o,w)
Rigidized Metals Corp., NY (cc,dd)
Rotometals, Calif (dd,ff)
Sel-Rex Corp., NJ (n,aa)—Ad p 356
Sherwatt Equipment & Mfg. Co., Inc., NY (ff)
Texas Instruments, Inc., Metals & Controls Div., Mass (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Ullmann, Inc., Wis (o,ee)
United Wire & Supply Corp., RI (ff)
Vanadium-Alloys Steel Co., Pa (aa)
Western Gold & Platinum Co., Sub. of Wilbur B. Driver Co., Calif (aa,cc,dd,ff)
Wildberg Bros. Smelting & Refining Co., Calif (n,o,v,w,z,aa,bb,cc,dd,ff)
Williams Gold Refining Co., Inc., NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Wilson, H.A. Div., Engelhard Industries, Inc., NJ (cc)

Slush Moldings

(see Moldings)

Solders

Abalon Precision Mfg. Corp., NY
All-State Welding Alloys Co., Inc., NY
Alofs Mfg. Co., Mich
American Emblem Co., Inc., NY
American Metal Climax, Inc., NY
American Products Corp., Ill
American Smelting & Refining Co., NY
Anchor Metal Co., Inc., NY
Belmont Smelting & Refining Works, Inc., NY
Bishop, J. & Co. Platinum Works, Pa
Chemical Development Corp., Mass
Composite Industrial Metals, Inc., RI
Consolidated Fruit Jar Co., NJ
Division Lead Co., Ill
Dyna-Therm Chemical Corp., Calif
Empire Metal Co., NY
Eutectic Welding Alloys Corp., NY
Falstrom Co., NJ
Farrelloy Co., Pa
General Findings & Supply Co., Industrial Div., Mass
Hayden Wire Works, Inc., Mass
Ideal Can Co., Mass
Indium Corp. of America, NY
Kenmore Machine Products, Inc., NY
Kester Solder Co., Ill
Kling Metal Spinning & Stamping Co., NY
L. & R. Mfg. Co., NJ

Langsenkamp, F.H. Co., Ind
Lucas-Milhaupt Engineering Co., Wis
Lundquist Tool & Mfg. Co., Inc., Mass
Magnesium Co. of America, Ind
Magnesium Products of Milwaukee, Inc., Wis
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass
Metal Goods Corp., Mo
Metallizing Co. of Los Angeles, Inc., Calif
Midwest Stamping & Mfg. Co., Ohio
National Lead Co., NY
Ney, J.M. Co., Conn
Presswork, Inc., Mich
Ren Plastics, Inc., Mich
Republic Metals Co., Inc., NY
Reynolds Aluminum Supply Co., Ga
Rockwell Engineering Co., Ill
Rotometals, Calif
Ruby Chemical Co., Ohio
Trenton Pipe Nipple Co., NJ
United Refining & Smelting Co., Ill
United Wire & Supply Corp., RI
Waterman Industries, Inc., Calif
Wayne Chemical Products Co., Mich
West Haven Foundry Co., Conn
Whitehead Metal Products Co., Inc., NY
Wildberg Bros. Smelting & Refining Co., Calif
Williams Gold Refining Co., Inc., NY

Spinnings

Ace Metal Spinning, Ill (a,b,c,d,e,f,g,h,j)
Acme Metal Spinning, Inc., Minn (a,b,c,d,e,f,g,h,j)
Aluminum Co. of America, Pa (a)
Aluminum Goods Mfg., Wis (a)
Aluminum Specialty Co., Wis (a)
American Aluminum Co., NJ (a,b)
Anchor Metal Spinning Co., Ohio (a,b,c,d,e,f,g,h,j)
Bartlett-Thompson Co. Inc., Mass (a,b,f,g)
Bergfels, William & Co., NJ (a,b,c,f,g,j)
Biersach & Niedermeyer Co., Wis (a,g)
Broadway Mfg. Co., Wis (a,b,c,f,g)
Brooks & Perkins, Inc., Mich (a,e,h)
Clover Industries, Inc., NY (a)
Commerical Shearing & Stamping Co., Ohio (a,b,e,f,g)
Craft Mfg. Co., Ill (a,b,c,d,f,g)
Craft Metal Spinning Co., Ill (a,b,f,g)
Cyril Bath Co., Ohio (a,g)
Dahlin, C.A. Co., Ill (a,b,e,f,g,h,j)
Dow Chemical Co., Mich (e)
Emerson-Sack-Warner Corp., Mass (a,b,c,e,f,g,h,j)
Garco Mfg. Co., Inc., Ill (a,b,e,f,g,h,j)
General Alloys Co., Mass (a,b,f)
Greene, G.G. Corp., Pa (a,g)
H & H Tube & Mfg. Co., Mich (b)
Hardy Mfg. Corp., Ind (a,g)
Kelsey-Hayes Co., Mich (g)
Kenmore Machine Products, Inc., NY (b)
Kling Metal Spinning & Stamping Co., NY (a,b,c,d,e,f,g,j)
Lukens Steel Co., Pa (a,b,e,f,g,h)
Magline, Inc., Mich (e)
Magnesium Co. of America, Ind (a,e)
Magnesium Products of Milwaukee, Inc., Wis (a,e)
Manufacturers Service, Inc., Ohio (a,b,g)
Mirro Aluminum Co., Wis (a)
Morse, Fred W. Co., RI (a,b,c,g,j)
Muncie Metal Spinning, Inc., Ind (a,b,g)
Murray, A.B. Co., Inc., NJ (a,b,f,g)
Murray Tube Works, Inc., NJ (a,b,g)
Pabst Engineering Equipment Co., Inc., NJ (a,b,c,e,f,g)
Perrin, Edward C. Co., NJ (a,b,g)
Phoenix Products Co., Wis (a,b,c,d,e,f,g,h,j)
Precision Metal Spinning Co., Mich (a,b,c,e,f,g)
Premier Metal Works, Inc., Ill (a,b,g)
Regal Ware, Inc., Wis (a,b,g)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY (b)
Reynolds Metals Co., Va (a)
Rockwell Engineering Co., Ill (a,b,c,g)
Ryerson, Joseph T. & Son, Inc., Ill (a,g)
Seattle Boiler Works, Inc., Wash (a,g)
Smith-Victor Corp., Ind (a)
Solar Aircraft Co., Calif (g)
Spincraft, Inc., Wis (a,b,d,e,f,g,h,j)
Stainless Metals, Inc., NY (c,f,h)
Stirrup Metal Products Corp., NJ (a,b,g)
Teiner, Roland Co., Inc., Mass (a,b,e,f,g,h)
Toledo Stamping & Mfg. Co., Ohio (a,b,g,h)
Torngren, C.W. Co., Inc., Mass (a,b,c,e,f,g,h,j)
Ward, H.H. Co., Pa (a,b)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (a,b,c,e,f,g)

Sprayed Coatings

(see Metallized Coatings)

Stampings, Punchings

(see also Drawn, Pressed Parts)

Abalon Precision Mfg. Corp., NY (a,b,c,g)
Ackermann Mfg. Co., W.Va (g)
Acme Mfg. & Gasket Co., Pa (a,b,f,g)
Acme Metal Spinning, Inc., Minn (a,b,c,e,f,g,j)
Acme Stamping & Wire Forming Co., Pa (a,b,g)
Acorn Sheet Metal Mfg. Co., Inc., Ill (a,g)
Acro Metal Stamping Co., Wis (a,b,f,g)
Adams, I.G. Metalware Co., Mo (a,b,c,e,f,g,j)
Advance Stamping Co., Mich (a,b,c,d,f,g,j)
Aerolite Electronics Corp., NJ (a,b,c,g)
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (g)
All-Form Metal Products Co., Ohio (a,b,c,d,e,f,g,j)
Allied Products Corp., Mich (a,g)
Alloy Products Corp., Wis (a,f,g,h)
Almco Steel Products Corp., Ind (a,b,g)
Alofs Mfg. Co., Mich (a,b,g)
Alox Mfg. Co., Mo (a,b,c,f,g)
Alpha Metals, Inc., NJ (a,g)
Aluminum Co. of America, Pa (a)
Aluminum Goods Mfg., Wis (a)
Aluminum Specialty Co., Wis (a,g)
American Aluminum Co., NJ (a,b)
American Brass Co., Sub. of Anaconda Co., NY (a,b,g)
American Emblem Co., Inc., NY (a,b,g)
American Mfg. Co., Tenn (a,g)
American Sheet Metal Works, Inc., Conn (a,b,g)
American Silver Co., NY (a,b,e,f,g)
American Stamping Co., Ohio (a,b,g)
Anchor Metal Spinning Co., Ohio (a,b,c,d,e,f,g,h,j)
Anderson, O.L. Co., Inc., Mich (a,b,c,e,f,g,h,j)
Anderson-Bolling Mfg. Co. Mich (a,g)
Anthes Div., Gleason Corp., Iowa (a,g)
Anti-Corrosive Metal Products Co., Inc., NY (g)
Armor Metal Products Co., Ohio (a,g)
Art Wire & Stamping Co., NJ (a,b,c,d,f,g)
Arvin Industries, Inc., Ind (a,g)
Ashtabula Mfg. Co., Ohio (g)
Associated Spring Corp., Wallace Barnes Steel Div., Conn (g)
Atkins Saw Div., Borg-Warner Corp., Ind (g)
Atlas Metal Parts Co., Wis (a,b,c,g)
Auburn Mfg. Co., Conn (a,b,c,d,e,f,g)—Ad p 450
Auel Industries, Pa (a,b,f,g)
Auld, D.L. Co., Ohio (a,b,c)
Autel Electronics Co., Precision Machine & Welding Div., NJ (a,b,c,e,g,h)
Automotive Rubber Co., Inc., Mich (f,g)
Backus Novelty Co., Pa (a,b,c,f,g)
Barclay Mfg. Co., Ind (c)
Barium Steel Corp., NY (g)
Bartlett-Thompson Co., Inc., Mass (a,b,f,g)
Bay State Stamping Co., Mass (a,b,g)
Beacon Metal Mfg. Co., NY (a,b,c,d,e,f,g,h,j)
Behringer Metal Works, Inc., NJ (a,b,c,g)
Belmet Products, Inc., NY (a,b,g)
Benjamin Electric Mfg. Co., Ill (a,b,g)
Bennett Mfg. Co., NY (a,b,e,g)
Bethlehem Steel Co., Pa (g)
Biddle Screw Machine Products Co., Ind (a,b,c,d,e,f,g,h)
Biersach & Niedermeyer Co., Wis (a,b,c,g)
Bingham Herbrand Corp., Bingham Stamping Div., Ohio (g)
Blacher Bros., Inc., RI (a,b,g)
Blaco Mfg. Co., Ohio (b,g)
Blickman, S., Inc., NJ (a,b,c,g)
Boots Aircraft Nut Corp., Conn (g)
Borg-Warner Corp., Ingersoll Products Div., Ill (g)
Brandt, Charles T., Inc., Md (a,b,e,f,g)
Brewer-Titchener Corp., NY (a,g)
Brooks & Perkins, Inc., Mich (a,e,h)
Burgess-Norton Mfg. Co., Ill (c)
Carbo Tool & Die Co., Ohio (c)
Carroll Pressed Metal, Inc., Mass (a,b,f,g)
Cartwright, R. Tube Products Co., Mich (a,b,g)
Clendenin Bros., Inc., Md (a,b)
Cleveland Metal Products Co., Ohio (a,b,c,f,g)
Cleveland Pressed Products Corp., Ohio (a,b,g)
Clover Industries, Inc., NY (a)
Cly-Del Mfg. Co., Inc., Conn (a,b,f,g,j)
Columbia Metal Stamping Co., Ohio (a,g)
Columbian Steel Tank Co., Mo (g)
Columbus Dental Mfg. Co., Ohio (a,b,c,g)
Columbus Jack Corp., Ohio (a,c,g)
Comerford Mfg. Co., Inc., Conn (a,b,c,e,f,g,j)
Commercial Shearing & Stamping Co., Ohio (a,b,f,g)
Composite Industrial Metals, Inc., RI (a,b,c,d,e,f,g,h,j)
Consolidated Fruit Jar Co., NJ (a,b,c,d,g,j)
Cooley, W.J. & Co., Tenn (a,b,g)
Craft Mfg. Co., Ill (a,b,c,d,f,g)
Croname Inc., Ill (a,b,f,g,j)
Crosby Co., NY (a,b,g)
Crown Metal Co., Wis (d)
Cuyahoga Stamping Co., Ohio (a,b,g)
Cyril Bath Co., Ohio (a,e,f,g,h)
Dahlin, C.A. Co., Ill (a,b,e,f,g,j)
Dana Corp., Auburn Div., Ind (g)
Danby Mfg. Co., Mich (a,b,g)
Dare Products, Inc., Mich (g)
Day Co., Minn (a,g)
Dayton Rogers Mfg. Co., Minn (a,b,g)
Dearborn Stamping Co., Mich (g)
Defiance Metal Products Co., Ohio (a,g)
Defiance Stamping Co., Ohio (g)
Detroit Stamping Co., Mich (a,b,g)
Dirilyte Co. of America, Inc., Ind (a,b)
Division Lead Co., Ill (d)
Dixon Corp., RI (k)
Doehler-Jarvis Div., National Lead Co. Ohio (a)
Dolin Metal Products, Inc., NY (g)
Dow Chemical Co., Dow Metal Products Co. Div., Mich (e)
Dudek & Bock Spring Mfg. Co., Ill (a,g)
Duplex Mfg. Corp., Ark (a,g)
Duplican Co., Inc., Mass (a,b,c,e,f,g,h,j)
Earley, Sam C. Corp., Ohio (a,b,g)
Eastern Tool & Mfg. Co., NJ (a,b,c,g)
Eastern Tool & Stamping Co., Inc., Mass (a,b,c)
Eby, Hugh H. Co., Pa (a,b,f)
Electric Auto-Lite Co., Ohio (a,b,g)
Electric Materials Co., Pa (b)
Electronic Parts Mfg. Co., NJ (c,f,g)
Ellwood City Iron & Wire Co., Pa (c)
Emerson-Sack-Warner Corp., Mass (a,b,c,f,g)
Empire Spring Co., Ohio (a,b,g)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Empire-Reeves Steel Div., Universal-Cyclops Steel Corp., Pa (g)
Enamel Products Co., Ohio (a,c)
Etched Products Corp., NY (a,b,g)
Evans, George Corp., Ill (a)
Eureka Electric Products Co., Pa (a,b)
Everard Tap & Die Corp., NY (a, b,f,g)
Fabristeel Products, Inc., Mich (g)
Falstrom Co., NJ (a,b,e,g)
Farwell Metal Fabricating, Minn (a, b,e,f,g)
Federal Tool Corp., Ill (a,b,c,g,)—Ad p 436
Federal Tool & Mfg. Co., Minn (a, b,c,f,g)
Figley Die & Stamping Co., Ohio (a, b,g)
FitzSimons Mfg. Co., Mich (a,b,g)
Fletcher Enamel Co., W.Va (a,b,c,d, e,f,g)
Follansbee Steel Corp., Sheet Metal Specialty Div., W.Va (a,b,g)
Forg, Peter Mfg. Co., Mass (a,b,c,g)
Fox Co., Ohio (a,b,c,g)
Fox Products Co., Pa (c)
Fryling Mfg. Co., Pa (a,b,f,g,j)
Garco Mfg. Co., Inc., Ill (a,b,c,e,f, g,h,j)
Gary Steel Products Corp., Va (a,g)
General Alloys Co., Mass (a,b,f)
General Chain & Mfg. Corp., Ohio (g)
General Extrusions, Inc., Ohio (a)
General Findings & Supply Co., Industrial Div., Mass (a,b,c,f,g)
General Gasket, Inc., Conn (a,b,c,d,g)
Geometric Stamping Co., Ohio (a,b,g)
Gerstenslage Co., Ohio (a,g)
Geuder, Paeschke & Frey Co., Wis (a, c,f,g)
Giant Grip Mfg. Co., Wis (a,c,e,f,g,h)
Gibson Electric Co., Pa (b)
Grammes, L.F. & Sons, Inc., Pa (a,b, g)
Grand Haven Stamped Products Co., Mich (a,b,g,j)
Grand Sheet Metal Products Co., Consumer Products Div., Ill (a,b,c,e,f, g,h,j)
Greene, G.G. Corp., Pa (a,b,e,f,g,j)
Greene Mfg. Co., Wis (a,g)
Grigoleit Co., Ill (a,g)
Guarantee Specialty Mfg. Co., Ohio (a,b,c,g,j)
H.K. Metal Craft Mfg. Corp., NY (a, b,c,g,j)
H P L Mfg. Co., Ohio (a,b,g)
Haigh Mfg. Co., Mich (a,b,f)
Hardy Mfg. Corp., Ind (a,b,g)
Headly Mfg. Co., Ill (a,b,c,e,f,g,h,j)
Heypian Mfg. Co., NJ (a,b,f,g)
Hoofer Mfg. Co., Ill (a,g)
Houston Blow Pipe & Sheet Metal Works, Tex (a,b,g)
Hunter Spring Co., Div. of American Machine & Metals, Inc., Pa (a,b,f,g)
Ideal Can Co., Mass (a,b,c,g)
Indium Corp. of America, NY (d)
Indus Corp., Ind (g)
Industrial Precision Products, Ill (a, b,c,e,f,g,h,j)
Industrial Products Div., General Tire & Rubber Co., Ind
Ingram-Richardson, Inc., Ind (g)
Inshield Die & Stamping Co., Ohio (a,b,g)
Instrument Specialties Co., Inc., NJ (b)
Interlake Mfg. Co., Mich (a,g)
Irwin-Sensenich Corp., Pa (g)
Jackson Auto Radiator, Ill (a,b,g)
Jarco Metal Products, NY (a,b,g,j)
Jervis Corp., Mich (a,b,g,h)
Judd Industries, Inc., Ohio (a,b,g)
K-D Mfg. Co., Tex (g)
Kaiser Steel Corp., Calif (g)
Kees, F.D. Mfg. Co., Neb (a,b,g)
Kelley Mfg. Co., Tex (a,b,g)
Kenmore Machine Products, Inc., NY (b)
Kickhaefer Mfg. Co., Wis (a,b,g)
King Laboratories, Inc., NY (a,b,c, f,g)
Kirchhof Patent Co., Inc., NY (a,b, c,f,g,j)
Kling Metal Spinning & Stamping Co., NY (a,b,c,d,e,f,g,j)
Koehler Mfg. Co., Mass (a,b,c,d,g)
Krueger & Hudepohl, Inc., Ohio (a, b,c,f,g)
Laminated Shim Co., Conn (a,b,g)
Lansing Stamping Co., Mich (g)
Larkin Specialty Mfg. Co., Calif (a,b, g)
Larson Tool & Stamping Co., Mass (a, b,c,e,f,g,h,j)
Laystrom Mfg. Co., Ill (a,b,c,f,g,j)
Leake Engineering Co., Mich (a,b,c, d,e,f,g,h,j)
Linden & Co., Inc., RI (a,b,g)
Littleford Bros. Inc., Ohio (a,b,c,f,g)
Lukens Steel Co., Pa (a,b,e,f,g,h)
Lundquist Tool & Mfg. Co., Inc., Mass (a,b,c,e,f,g,h)
Lynn, Gary Co., Ohio (a,b,g)
Machine Products Corp., Ohio (a,b,d,f, g)
Magline, Inc., Mich (e)
Magnesium Co. of America, Ill (a,e)
Magnesium Products of Milwaukee, Inc., Wis (a,e)
Magnetic Stamping Co., Pa (a,b,g)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (b)
Maloney, F.H. Co., Tex (g)
Manganese Steel Forge Co., Pa (g)
Manufacturers Service, Inc., Ohio (a, b,g)
Mayville Metal Products Co., Wis (a, b,g)
McDowell Mfg. Co., Pa (a,b,g)
McKinney Mfg. Co., Pa (a,b,e,f,g)
McLanahan & Stone Corp., Pa (c,g)
Melco Wire Products, Calif (a)
Melray Mfg. Co., Ill (a,b,c,d,e,f,g,h,j)
Metal Forming Corp., Div. of Vanadium-Alloys Steel Co., Pa (a,b,f,g)
Metal Parts & Stamping Co., Ohio (a,b,c,f,g,h,j)
Metallo Gasket Co., NJ (a,b,c,d,f,g,j)
Metallurgical Products Co., Pa (a,b,f, h,j)
Micacraft Products, Inc., NJ (a)
Midwest Stamping & Mfg. Co., Ohio (a,b,f,g)
Milwaukee Stamping Co., Wis (a,b,g)
Mirro Aluminum Co., Wis (a)
Misner Corp., Neb (a,b,c,g)
Monarch Tool & Mfg. Co., Ky (a,b,c, g)
Morrison Steel Products, Inc., NY (g)
Morse, Fred W. Co., RI (a,b,c,g,j)
Morton Mfg. Co., Ill (a,g)
Mueller Machine Products, Inc., Wis (a,b,c,d,f,g)
National Gasket & Washer Mfg. Co., Inc., NY (a,b,c,d,e,f,g,h,j)
National Lead Co., NY (a,c,h)
National Lock Co., Ill (a,b,c,d,g)
National Metal Products Co., Pa (a, c,g)
National Supply Co., Pa (g)
Nichols, L.O. & Son Mfg. Co., Mo (a, b,c,g)
Nigg Engineering Corp., Calif (a,b,c,g)
Noera Mfg. Co., Conn (a,b,g)
Noland Tank & Galvanizing Co., Tenn
Norcross, C.S. & Sons Co., Ill (g)
Nylok Corp., NJ (a,b,c,e,g)
Ohio Nut & Washer Co., Ohio (a,g)
Olean Electro Plating Co., NY (a,b,g)
Ormond Mfg., Co., Inc., NJ (a,b,f,j)
Pabst Engineering Equipment Co., Inc., NJ (a,b,c,e,f,g)
Paragon Spring Co., Ill (a,b,c,f,g)
Parish Pressed Steel Div., Dana Corp., Pa (a,g)
Parker, Charles Co., Conn (a,f)
Parker Metal Goods Co., Mass (a,b,g)
Peck Spring Co., Conn (a,b,c,f,g,h)
Peerless Products Industries, Ill (a, b,g)
Pemco Wheel Co., Mich (g)
Penn Fibre & Specialty Co., Inc., Pa (a,b,c,d,e,f,g,j)
Penrod, Floyd & Sons Tool & Engineering Corp., Ind (a,b,g)
Perrin, Edward C. Co., NJ (a,b,g)
Peterson Products Corp., Ill (a,b,f,g)
Philadelphia Enameling Works Inc., Pa (a,b,g)
Phoenix Iron & Steel Co., Pa (a,g)
Pioneer Stamped Products Co., NY (a, b,c,d,e,f,g,h)
Pittsburgh Forgings Co., Mich (g)
Plume & Atwood Mfg. Co., Conn (a,b,f,g)
Porter, H.K., Inc., Forge & Fittings Div., Ohio (a,g)
Powell Pressed Steel Co., Ohio (a,g)
Premier Metal Works, Inc., Ill (a,b, f,g)
Pressed Steel Co., Pa (a,b,d,f,g,j)
Presswork, Inc., Mich (a,b,c,d,f,g,j)
Prestole Corp., Ohio (a,g)
Queen Products Co., Inc., Ky (a,b,g)
Reed & Prince Mfg. Co., Mass (a,b, c,g)
Regal Ware, Inc., Wis (a,b,g)
Reichert Float & Mfg. Co., Ohio (a,b,c,d,f,j)—Ad p 464
Reliable Spring & Wire Forms Co., Ohio (a,b,f,g)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY (a, b,c,f,g,j)
Reynolds Metals Co., Va (a)
Rochester Novelty Works, Inc., NY (a,g)
Rockwell Engineering Co., Ill (a,b,c,g)
Rockwell - Standard Corp., Stamping Div., NY (a,b,d,f,g)—Ad p 458
Rohr Aircraft Corp., Calif (a,e,g,h)
Rolock, Inc., Conn (f)
Roth Steel Products Co., Ohio (g)
Ryerson, Joseph T. & Son, Inc., Ill (a,g)
S.T.D. Div., Pierce Industries, Inc. of Ohio, Ohio (a,g)
St. Marys Carbon Co., Pa (b)
Sargent & Greenleaf, Inc., NY (a,b,g)
Scovill Mfg. Co., Mill Products Div., Conn (a,b,c,f,g)
Security Cos., Mich (a)
Security Sash & Screen Co., Mich (a)
Serwell Products Co., Ohio (b,g)
Shakeproof Div., Illinois Tool Works, Ill (b,g)
Shank Metal Products Co., NY (a,g)
Shelby Mfg. Co., Ohio (g)
Sheller Mfg. Corp., Mich (g)
Sierra Electric Corp., Calif (b,g)
Sillcocks Miller Co., NJ (a,b,f,g)
Simonsen Metal Products Co., Ill (a, g)
Sinclair Co., Mass (b,g)
Sioux City Foundry & Boiler Co., Iowa (g)
Smithers Tool & Machine Products, Inc., NY (g)
Smith-Victor Corp., Ind (a,g)
Smoot-Holman Co., Calif (g)
Sommer Metalcraft Corp., Ind (a,g)
South River Metal Products Co., Inc., NJ (a,e,g)
Southern Car & Mfg. Co., Inc., Ala (a,b,g)
Southwestern Porcelain Steel Corp., Okla (g)
Spincraft, Inc., Wis (a,b,g)
Stainless Metals, Inc., NY (c,f,h)
Stamford Metal Specialty Co., Inc., NY (a,f,g)
Standard Forge & Axle Co., Inc., Ala (g)
Standard Nut & Bolt Co., RI (a,b,f,g)
Standard Steel Sections, Inc., NY (a, b,c,g)
Stanley Industrial Sales, Stanley Works, Conn (g)
Star Heel Plate Co., Inc., NJ (g)
Star Stamping Co., Mich (a,b,g)
Staver Co., Inc., NY (a,b,c,d,e,f,g,h,j)
Steel Heddle Mfg. Co., Pa (a,b,c,e,f,g, h,j)
Steel Industries, Inc., Ind (a,b,g)
Steinen, Wm. Mfg. Co., NJ (a,b,c,g)
Stenman, Brer F., Mass (a,g)
Stimpson, Edwin B. Co., Inc., NY (a,o,f,g,j)
Stirrup Metal Products Corp., NJ (a, b,c,g)
Superior Mfg. Co., Pa (g, j)
Superior Spinning & Stamping Co., Ohio (a,b,f,g)
Sylvania Electric Products Inc., Parts Div., Pa (a,b,c,f,g)
Textile Shield Co., Inc., Mass (a,b,g)
Thompson Products, Inc., Ohio (g)
Thompson-Bremer & Co., Ill (a,b,c,f, g,h)
Titchener, E.H. & Co., NY (a,b,f,g)
Toledo Stamping & Mfg. Co., Ohio (a,b,g,h)
Transue & Williams Steel Forging Corp., Ohio (f,g)
Triangle Stamping Co., Ohio (a,b,c,d,f, g,j)
Turner & Seymour Mfg. Co., Conn (a, b,g)
United Metal Products Corp., Mich (a,b,c,g)
United Screw & Bolt Corp., Ill (a, b,g)
United Shoe Machinery Corp., Mass (a,b,f,g,j)
U.S. Gasket & Shim Co., Ohio (a, b,c,d,e,f,g,h,j)
United-Carr Fastener Corp., Mass (a, b,g)
Unity Machine & Tool Corp., Pa (a, b,g)
Van Valkenburg, L.A. Co., Mass (a, b,c,f,g)
Variety Stamping Corp., Ohio (a,b,c,g)
Volkert Stampings, Inc., NY (b,f,g)
WLS Stamping Co., Ohio (a,b,c,d,e, f,g,h,j)
Wabash Metal Products Co., Inc., Ind (a,b,g)
Wagner, E.P. Mfg. Co., Wis (a,b,c,g, j)
Wagner Specialty Co., Wis (a,b,c,g, j)
Wall, P. Mfg. Co., Pa (a,b,g)
Wall Tube & Metal Products Co., Tenn (g)
Ward, H.H. Co., Pa (a,b,c,f,g,j)
Waterbury Buckle Co., Conn (a,g,j)
Waterbury Cos., Inc., Conn (a,b,g)
Waterbury Pressed Metal Co., Conn (a,b,f,g)
Waterman Industrial, Inc., Calif (a, b,g)
Wayne Foundry & Stamping Co., Mich (a,b,e,g,h)
Weatherhead Co., Ind (a,b,g,h)
Weber-Knapp Co., NY (a,g)
Welding Apparatus Co., Ill (a,f,g)
Wesbar Stamping Corp., Wis (a,g)
Wesco Spring Co., Ill (g)
Western Tool & Die Works, Ore (a,b, g)
Wilder Mfg. Co., Inc., Calif (a,c,g)
Williams, F.B. Co., Ill (g)
Williams, H.E. Products Co., Mo (a, b,c,g,j)
Wilson-Hurd Mfg. Co., Inc., Wis (a)
Wirth, Carl & Son, Inc., NY (a,b,c,g)
Wisconsin Gasket & Mfg. Co., Wis (a,b,g)
Wisconsin Tool & Stamping Co., Ill (a,b,d,f,g,j)
Wood, John Co., Minn (g)
Woolf Aircraft Products, Inc., Mich (a,b,g)
Worcester Pressed Steel Co., Mass (a, b,c,e,f,g,h,j)
Worcester Stamped Metal Co., Mass (a,b,e,f,g,h,j)
Worth Co., Wis (a,b,c,g)
Wrought Washer Mfg. Co., Wis (a,b, d,e,f,g,h,j)
Wuest Bros., Inc., Ky (a,b,c,f,g)
Youngstown Kitchens Div., American Standard Co., Ohio (a,g)
Youngstown Mfg., Inc., Ohio (a,g)
Youngstown Sheet and Tube Co., Ohio (g)

Steatite

(see Ceramics)

Steel, Carbon

Acme-Newport Steel Co., Ky (w,z,cc)
Advance Screw Products Co., Inc., Wis (o)
Advance Stamping Co., Mich (dd)
Ainsworth-Precision Castings Co., Div of Harsco Corp., Mich (ee)
Alan Wood Steel Co., Pa (q,w,z,cc,dd)
Albert Pipe Supply Co., NY (ee)
Albert Wright Screw Machine Products Calif (bb)
Alco Products, Inc., NY (q,aa)
Allegheny Ludlum Steel Corp., Pa (dd)
Alloy Metal Powders, Inc., Iowa (aa)
Almco Steel Products Corp., Ind (o, z,bb,cc,dd)
Amalgamated Steel Corp., Ohio (o,bb)
American Cast Iron Pipe Co., Ala (ee)
American Metal Products, Inc., Ohio (z,cc)
American Silver Co., NY (v,dd)
American Steel and Wire Div., U. S. Steel Corp., Ohio
(q)—Ad pp 90-91
Ames, W. & Co., NJ (o)
Anchor Drawn Steel Co., Div. of Vanadium-Alloys Steel Co., Pa (bb,ff)
Aristoloy Steel Div., Copperweld Steel Co., Ohio (o,q,w)
Armco Steel Corp., Ohio (o,z,bb,cc, dd,ff)
Armco Steel Corp., Sheffield Div., Mo (o,q,w,z,bb,cc,dd,ff)
Athenia Steel Div., National Standard Co., NJ (dd)
Atlantic Steel Co., Ga (o,q,w,z,bb,cc, dd,ee,ff)
Austenal Co., Div. of Howe Sound Co., NY (w)
Babcock & Wilcox Co., Tubular Products Div., Pa (ee)
Barium Steel Corp., NY (q,w,z,ee)
Baxter Foundry & Machine Works, Inc., Id (o,z,bb,cc,dd)
Bethlehem Steel Co., Pa (o,q,z,bb, cc,dd,ee,ff)
Biddle Screw Products Co., Ind (o,bb, ee)
Bliss & Laughlin, Inc., Ill (o)
Brainard Steel Div., Sharon Steel Corp., Ohio (ee)
Burkhardt Steel Co., Colo (o,z,cc,dd, ee)
Byers, A.M. Co., Pa (o,q,w,z,cc,dd)
Cannon-Muskegon Corp., Mich (w)
Carpenter Steel Co., Webb Wire Div., NJ (ff)
Caspers Tin Plate Co., Ill (cc,dd)
Castle, A.M. & Co., Ill (o,z,bb,cc, dd,ee,ff)
Central Fabricators, Inc., Ohio (z, bb,cc,ee)
Chicago Steel Service Co., Ill (o,z, bb,cc,dd)
Clad-Rex Corp., Ill (cc)
Clark Perforating Co., Mich (cc,dd)
Clayton Mark & Co., Ill (ee)
Colonial Steel Div., Vanadium-Alloys Steel Co., Pa (o,q,w,z,bb,cc,ff)
Columbia-Geneva Steel Div., U. S. Steel Corp., Calif (o,q,z,cc,dd,ee)
Connors Steel Div., H.K. Porter Co., Inc., Ala (o,q,w,dd)
Continental Steel Corp., Ind (o,q,bb,ff)
Crucible Steel Co. of America, Pa (o,q,w,z,bb,cc,dd,ee,ff)
Crucible Steel Co. of America, Titanium & Vacuum Metal Products Div., Pa (o,q,z,bb,cc,dd,ff)
Cumberland Steel Co., Md (o)
Designers Metal Corp., Ill (cc)
Detroit Steel Corp., Portsmouth Div., Mich (q,w,bb,cc)
Dixon Sintaloy, Inc., Conn (o)
Dudek & Bock Spring Mfg. Co., Ill (dd,ff)
Eaton Mfg. Co., Reliance Div., Ohio (o,ff)
Edgcomb Steel & Aluminum Corp., NJ (o,z,cc,dd)
Elliott Bros. Steel Co., Pa (cc,dd)
Empire-Reeves Steel Div., Universal-Cyclops Steel Corp., Pa (z,cc)
Enterprise Wheel & Car Corp., Va (o, z,cc)
Eynon-Dakin Co., Mich (ee)
Finkl, A. & Sons Co., Ill (w)
Follansbee Steel Corp., W.Va (cc,dd)
Forg, Peter Mfg. Co., Mass (cc)
Fort Howard Steel & Wire Co., Wis (o)
Franklin Steel Div., Borg-Warner Corp., Pa (o)
Frasse, Peter A. & Co., Inc., NY (o,bb,cc,dd,ee,ff)
Fromson Orban Co., Inc., NY (ee)
Gary Steel Products Corp., Va (o,z,cc)
General Chain & Mfg. Corp., Ohio (ff)
General Motors Corp., Rochester Products Div., NY (ee)
Granite City Steel Co., Ill (w,z,cc)
Great Lakes Steel Corp., Div. of National Steel Corp., Mich (z,cc,dd)
Green River Steel Corp., Ky (o,q,w)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (o, bb,ee,ff)
Haydon Corp., NY (ee)
Houston Blow Pipe & Sheet Metal Works, Tex (o,z,cc)
Inland Steel Co., Ill (o,z,cc,dd)
Inshield Die & Stamping Co., Ohio (cc)
Isaacson Iron Works, Wash (q,w)
Jackson Steel Products, Inc., NY (ee)
Jones & Laughlin Steel Corp., Pa (o, q,z,bb,cc,dd,ee,ff)
K-D Mfg. Co., Tex (o)
Kaiser Steel Corp., Calif (o,q,w,z,bb, cc,dd,ee)
Keystone Drawn Steel Co., Pa (o)
Keystone Steel & Wire Co., Ill (w, bb)
Kinkead Industries, Inc., Ill (o,z,bb, cc,dd)
Korhumel Steel and Aluminum Co., Ill (o,z,bb,cc,dd,ff)
Laclede Steel Co., Mo (o,q,w,bb,dd, ee,ff)
Larson, Charles E. & Sons, Inc., Ill (o)
La Salle Steel Co., Ill (o)
Le Tourneau, R.G., Inc., Tex (z)
Levinson Steel Co., Pa (o,z,bb,cc,dd)
Lock Joint Tube Co., Inc., Ind (ee)
Lockhart Iron & Steel Co., Pa (o,q,z, bb,cc,dd,ee)
Lockport Mfg. Co., Ill (z)
Lukens Steel Co., Pa (w,z)
Lundquist Tool & Mfg. Co., Inc., Mass (bb,cc,dd,ee,ff)
Luria Engineering Co., Pa (z,bb,cc)
Mahon, R.C. Co., Mich (o,z,cc,dd)
Makepeace, D.E. Div., Engelhard Industries Inc., Mass (o,dd,ee)
McCarter Iron Works, Inc., Pa (o,z,bb, cc)
McGregor-Michigan Corp., Mich (z)
McInnes Steel Co., Pa (o)
McLouth Steel Corp., Mich (cc,dd)
Metal Forming Corp., Div. of Vanadium-Alloys Steel Co., Ind (ee)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Michigan Seamless Tube Co., Mich (ee)
Midvale-Heppenstall Co., Pa (w)
Modern Plating Corp., Ill (z)
Morrisville Foundry Co., Inc., Vt (z, bb,cc,dd)
Murray, A.B. Co., Inc., NJ (ee)
Narragansett Boiler Works, Inc., RI (o,z,bb,cc,ee)
National Galvanizing Co., Pa (z,bb, cc,ee)
National Lock Washer Co., NJ (ff)
National Supply Co., Pa (o,q,w)
National Tube Div., U.S. Steel Corp., Pa (ee)
National U.S. Radiator Corp., Plastic Metals Div., Pa (aa)
National-Standard Co., Mich
(dd,ff)—Ad p 421
Nesor Alloy Products Co., NJ (ff)
New York Iron Roofing & Corrugating Co., Inc., NJ (cc)
Newman-Crosby Steel Co., RI (dd)
Nikoh Tube Co., Ill (bb,cc,dd,ee)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb,ee)
Northwestern Steel & Wire Co., Ill (o,q,w,z,bb,ff)
Norwalk Powdered Metals, Inc., Conn (aa)
Ohio Seamless Tube Div., Copperweld Steel Co., Ohio (ee)
Ormond Mfg. Co., Inc., NJ (cc,dd,ff)
Pacific States Steel Corp., Calif (o, q,w)
Pacific Tube Co., Calif (o)
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa (ff)
Peninsular Steel Co., Mich (o,z)
Phoenix Iron & Steel Co., Pa (z)
Phoenix Mfg. Co., Ill (o)
Pittsburgh Forgings Co., Mich (o,q)
Pittsburgh Steel Co., Pa (q,w,bb,cc, dd,ee,ff)
Precision Tube Co., Inc., Pa (ee)
Purdy, A.R. Co., Inc., NJ (o,z,bb, cc,dd,ff)
Rathbone Corp., Mass (o,bb)
Reactive Metals, Inc., Ohio (cc)
Republic Steel Corp., Ohio
(o,q,w,z,bb,cc,dd,ee,ff)—Ad pp 84-85
Reynolds Aluminum Supply Co., Ga (cc)
Rigidized Metals Corp., NY (cc,dd)
Riverside-Alloy Metal Div., H.K. Porter Co., Inc., NJ
(ff)—Ad p 160
Rodney Metals, Inc., Mass (v,dd)
Roebling's, John A. Sons Div., Colorado Fuel & Iron Corp., NJ (bb, dd,ff)
Rome Mfg. Div., Revere Copper & Brass Inc., NY (ee)
Rome Strip Steel Co., Inc., NY (o, z,dd,ff)
Ross-Meehan Foundries, Tenn (o)
Ryerson, Joseph T. & Son, Inc., Ill (o,q,z,bb,cc,dd,ee,ff)
St. Louis Steel Casting, Inc., Mo (o)
Sandusky Foundry & Machine Co., Ohio (ee)
Sandvik Steel, Inc., NJ
(dd)—Ad p 83
Saran Lined Pipe Co., Div. of Michigan Pipe Co., Mich (ee)
Sawhill Tubular Products, Inc., Pa (ee)
Scudder, E.J. Foundry & Machine Co., NJ (bb,ee)
Service Steel Div., Van Pelt Corp., Mich (ee)
Sharon Steel Corp., Pa (q,w,z,cc,dd)
Sharpsville Steel Fabricators, Inc., Pa (o,z,bb,cc)
Shaw-Kendall Engineering Co., Ohio (ee)
Sherwatt Equipment & Mfg. Co., Inc., NY (ff)
Simonds Saw & Steel Co., Mass (o,cc)
Smith-Moon Steel Co., Inc., Kan (o, z,cc)
Solar Steel Corp., Ohio (o,bb,cc,dd,ee)
Sonken-Galamba Corp., Kan (z,bb,cc, ee)
Stainless and Strip Div., Jones & Laughlin Steel Corp., Ohio
(dd)—Ad p 89
Southern Fabricating Co., Inc., Ala (ee)
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa (q,w)
Star Heel Plate Co., Inc., NJ (o,z, bb,cc,dd,ee,ff)
Sun Steel Co., Ill (o,q,z,bb,cc,dd)
Superior Drawn Steel Co., Pa (o,bb,ff)
Superior Steel Div., Copperweld Steel Co., Pa (dd)
Superior Tube Co., Pa (ee)
Sylvania Electric Products, Inc., Parts Div., Pa (ff)
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (o,q,z,cc,dd)
Thomas Strip Div., Pittsburgh Steel Co., Pa (dd)
Thompson Industries, Inc., NY (bb)
Thompson Wire Co., Mass (dd)
Timken Roller Bearing Co., Steel & Tube Div., Ohio (ee)
Topeka Foundry & Iron Works Co., Inc., Kan (o,z,bb,cc,dd)
Trojan Steel Co., W.Va (o,z,bb,cc,dd)
Tube Distributors Co., Inc., NY (ee)
Tube Reducing Corp., NJ (ee)
Uddeholm Co. of America, Inc., NY (bb,dd,ee)
Udylite Corp., Mich (n)
Ullmann, Inc., Wis (o,ee)
Union Iron Works, Wash (o,z,cc,dd,ee)
Union Steel Corp., NJ (dd)
United Screw & Bolt Corp., Ill (bb, cc,dd,ff)
U.S. Challenge & Challenge Co., Ill (bb)
U.S. Gasket & Shim Co., Ohio (cc,dd)
U.S. Steel Corp., Pa (o,q,z,cc,dd)
U.S. Steel Supply Div., U.S. Steel Corp., Ill (o,z,cc,dd,ee)
Vanadium-Alloys Steel Co., Pa (o,q, w,z,aa,bb,cc,ff)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Vulcan Rail & Construction Co., NY (o,dd,ee)
Vulcan-Kidd Steel Div., H.K. Porter Co., Inc., Pa (o,q,w,bb,ff)
Wallace Tube Co., Div. of Wallace Supplies Mfg. Co., Ill (ee)
Wal-Mar Corp., Ill (ee)
Washburn Wire Co., Phillipsdale Div., RI (q,bb,dd)
Weirton Steel Co., Div. of National Steel Corp., W.Va (cc)
Western Automatic Machine Screw Co., Div. of Standard Screw Co., Ohio (o)
Western Iron & Foundry Co., Inc., Kan (o,z,bb,cc,dd)
Wheatland Tube Co., Pa (ee)
Wickwire Bros., Inc., NY (bb,ff)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (w,z)
Wilson Steel & Wire Co., Ill (ff)
Wisconsin Steel Co., Div. of International Harvester Co., Ill (o,q)
Wycoff Steel Co., Pa (o,z)
Youngstown Sheet and Tube Co., Ohio (o,z,bb,cc,dd,ee,ff)

Steel, Carbon—Castings

Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa
Adirondack Steel Casting Co., NY
Advance Foundry Co., Ohio
Allied Steel Castings Co., Ill
All-Metals Precision Casting Corp., NY
Alloy Cast Steel Co., Ohio
Alloy Precision Castings Co., Ohio
Alloy Steel & Metals Co., Calif
American Cast Iron Pipe Co., Ala
American Steel Foundries, Ill
Arneson Foundry Co., Wis
Arwood Corp., NY
Atlantic Foundry Co., Ohio
Atlantic Steel Castings Co., Pa
Austenal Co., Div. of Howe Sound Co., NY
Auto Specialties Mfg. Co., Mich
Baldwin-Lima-Hamilton Corp., Pa
Bay City Electric Steel Casting Co., Mich.
Beaver Valley Alloy Foundry Co., Pa
Bethlehem Steel Co., Pa
Birdsboro Steel Foundry & Machine Co., Pa
Blaw-Knox Co., Pa
Bone Engineering Corp., Calif
Calumet Steel Castings Corp., Ind
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich
Commercial Steel Casting Co., Ohio
Crucible Steel Casting Co., Pa
Dayton Steel Foundry Co., Ohio
Dodge Steel Co., Pa
Eastern Malleable Iron Co., Del
Electric Steel Castings Co., Ind
Electric Steel Foundry Co., Ore
Electrocast Steel Foundry Co., Ill
Empire Foundry Co., Inc., Calif
Empire Steel Castings, Inc., Pa
Engineered Castings Div., American Brake Shoe Co., NY
Falk Corp., Wis
Farrel-Birmingham Co., Inc., Conn
Federal Steel Products Corp., Tex
Fort Pitt Steel Casting Div., Pittsburgh Steel Foundry Corp., Pa
General Electric Co., Foundry Dept., NY
General Steel Castings Corp., Ill
Glover Machine Works, Ga
Goslin Birmingham Mfg. Co., Inc., Ala
Grede Foundries, Inc., Wis
Gunite Foundries Corp., Ill
Hartford Electric Steel Corp., Conn
Hica, Inc., La
Hitchiner Mfg. Co., Inc., NH
Howard Foundry Co., Ill
Hughes Tool Co., Tex
Humphrey Castings, Inc., Calif
Illinois Precise Casting Co., Ill
Kay-Brunner Steel Products, Inc., Calif
LFM Mfg. Co., Inc., Sub. of Rockwell Mfg. Co., Kan
Lebanon Steel Foundry, Pa
Lectromelt Casting Div., Akron Standard Mold Co., Ohio
Liberty Foundry Co., Mo
Lincoln Iron Works, Vt
Los Angeles Steel Casting Co., Calif
Mackintosh-Hemphill Div., E.W. Bliss Co., Pa
Manco Products, Inc., Mich
Massillon Steel Casting Co., Ohio
Mercast Mfg. Corp., Calif
Midwest Precision Castings Co., Ohio
Minneapolis Electric Steel Castings Co., Minn
Misco Precision Casting Co., Mich
Missouri Steel Castings Co., Mo
Monroe Steel Castings Co., Mich
Montague Machine Co., Mass
National Malleable & Steel Castings Co., Ohio
National Precision Casting Corp., Div. of Beryllium Corp., Pa
National Supply Co., Pa
Ohio Steel Foundry Co., Ohio
Oklahoma Steel Castings Div., American Steel & Pump Corp., Okla
Olympic Steel Works, Wash
Omaha Steel Works, Neb
Pelton Steel Casting Co., Wis
Penn Steel Castings Co., Pa
Picco, Inc., Calif
Pittsburgh Steel Foundry Corp., Pa
Posey Iron Works, Inc., Pa
Pratt & Letchworth Div., Dayton Malleable Iron Co., Inc., NY
Precision Founders, Inc., Calif
Quaker Alloy Casting Co., Pa
Quality Electric Steel Castings, Inc., Tex
Quincy Steel Casting Co., Mass
Racine Steel Castings Co., Wis
Reliance Steel Castings Co., Pa
Rockwell Engineering Co., Ill
Ross-Meehan Foundries, Tenn
Ryerson, Joseph T. & Son, Inc., Ill
St. Louis Steel Casting, Inc., Mo
Sandusky Foundry & Machine Co., Ohio
Sawbrook Steel Castings Co., Ohio
Scullin Steel Co., Mo
Sivyer Steel Casting Co., Wis
Skookum Co., Inc., Ore
Sorbo-Mat Process Engineers, Mo
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa
Star Heel Plate Co., Inc., NJ
Strong Steel Foundry Co., NY
Superior Foundry, Inc., Ohio
Superior Steel & Malleable Castings Co., Mich
Swedish Crucible Steel Co., Mich
Texas Foundries, Inc., Tex
Texas Steel Co., Tex
Thys Co., Calif
Union Iron Works, Wash
Union Spring & Mfg. Co., Pa
Unitcast Corp., Ohio
—Ad p 467
U.S. Pipe & Foundry Co., Ala
Utility Steel Foundry, Calif
Valley Steel Casting Co., Mich
Vascoloy-Ramet Corp., Ill
Vulcan Iron Works, Pa
Washington Iron Works, Wash
West Steel Casting Co., Ohio
Westinghouse Electric Corp., Materials Mfg. Dept., Pa
Westlectric Castings, Inc., Calif
Worthington Corp., NJ

Steel, Heat and Corrosion Resistant

Acme Tube, Inc., NJ (ee)
Advance Stamping Co., Mich (dd)
Albert Pipe Supply Co., Inc., NY (ee)
Albraco Metals Co., NY (o,q,bb,ee,ff)
Alco Products, Inc., NY (q)
Allegheny Ludlum Steel Corp., Pa
(o,q,w,z,bb,cc,dd,ee,ff)—Ad p 87
Alloy Metal Powders, Inc., NY (aa)
Alloy Metal Products, Inc., Iowa (o,q,w)
Alofs Mfg. Co., Mich (dd)
American Cast Iron Pipe Co., Ala (ee)
American Silver Co., NY (v,dd,ee,ff)
American Steel & Wire Div., U.S. Steel Corp., Ohio
(ff)—Ad pp 90-91
Anchor Drawn Steel Co., Div. of Vanadium-Alloys Steel Co., Pa (bb,ff)
Arcos Corp., Pa (ff)
Aristoloy Steel Div., Copperweld Steel Co., Ohio (o,q)
Armco Steel Corp., Ohio (o,q,v,z,bb,cc,dd,ff)
Athenia Steel Div., National-Standard Co., NJ (dd)
Austenal Co., Div. of Howe Sound Co., NY (w)
Babcock & Wilcox Co., Tubular Products Div., Pa (ee)
Bethlehem Steel Co., Pa (o,q,z,bb,cc,dd,ee,ff)
Biddle Screw Products Co., Ind (o,bb,ee)
Bishop, J. & Co., Platinum Works, Pa (ee)
Brinkerhoff Brass & Bronze Works, Inc., NY (z,bb,cc)
Brush Beryllium Co., Ohio (v,dd)
Byers, A.M. Co., Pa (o,q,w,z,cc,dd)
Cannon-Muskegon Corp., Mich (w)
Carlson, G.O., Inc., Pa (o,z,cc)
Carpenter Steel Co., Pa (o,q,w,bb,dd,ee,ff)
Carpenter Steel Co., Alloy Tube Div., NJ (ff)
Carpenter Steel Co., Webb Wire Div., NJ (ff)
Castle, A.M. & Co., Ill (o,q,z,cc,dd,ff)
Central Fabricators, Inc., Ohio (z,bb,cc,ee)
Chromalloy Corp., NY (cc)
Colonial Steel Div., Vanadium-Alloys Steel Co., Pa (o,q,w,z,bb,cc,ff)
Columbia-Geneva Steel Div., U.S. Steel Corp., Calif (o,q,w,z,cc,dd,ee,ff)
Crucible Steel Co. of America, Pa
(o,q,w,z,bb,cc,dd,ee,ff)—Ad p 93
Crucible Steel Co. of America, Titanium & Vacuum Metal Products Div., Pa (o,q,z,bb,cc,dd,ff)
Curtiss-Wright Corp., Metals Processing Div., NY (ee)
Damascus Tube Co., Pa (ee)
Dixon Sintaloy, Inc., Conn (o)
Driver, Wilbur B. Co., NJ (y,bb,dd,ff)
Dudek & Bock Spring Mfg Co., Ill. (dd, ff)
Eastern Stainless Steel Corp., Md (z,cc,dd)
Eaton Mfg. Co., Reliance Div., Ohio (o,ff)
Edgcomb Steel & Aluminum Corp., NJ (o,z,cc,dd)
Electric Steel Foundry Co., Ore (o,q,w,z,bb,cc,dd,ee,ff)
Erskine Precision Wire Corp., Pa (ff)
Eynon-Dakin Co., Mich (ee)
Firth Sterling, Inc., Pa (o,q,w,bb,ff)
Frasse, Peter A. & Co., Inc., NY (o,bb,cc,dd,ee,ff)
Fromson Orban Co., Inc., NY (ee)
Gary Steel Products Corp., Va (o,z,cc)
General Electric Co., Metallurgical Products Dept., Mich (aa,bb,cc,dd)
Green River Steel Corp., Ky (o,q,w)
Hamilton Watch Co., Precision Metals Div., Pa (v,cc,dd,ff)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (o,z,bb,dd,ee,ff)
Haydon Corp., NY (ee)
Hexcel Products, Inc., Calif (v)
Hoeganaes Sponge Iron Corp., NJ
(aa)—Ad p 462
Industrial Stainless Steels, Inc., Mass (o,q,z,bb,cc,dd,ee,ff)
Jessop Steel Co., Pa (o,q,z,cc,dd,ee)
Johnson, A. & Co., Inc., NY (ee)
Jones & Laughlin Steel Corp., Pa (o,q,cc,dd)
Joslyn Stainless Steels, Ill (o,q,w,bb,ff)
Kaiser Steel Corp., Calif (o,q,w,z,bb,cc,dd)
Kelsey-Hayes Co., Mich (o,q,z,cc)
Kinkead Industries, Inc., Ill (cc,dd)
Kirk & Blum Mfg Co., Ohio (z,cc)
Kolcast Industries Div., Thompson Products, Inc., Ohio (q,w)
Krueger Fabricating Co., Inc., Wis (cc)
Larson, Charles E. & Sons Inc., Ill (o)
Latrobe Steel Co., Pa
(o,q,w)—Ad p 95
Lockport Mfg. Co., Ill (z)
Lukens Steel Co., Pa (w,z)
Lundquist Tool & Mfg. Co., Inc., Mass (bb,cc,dd,ee,ff)
Makepeace, D.E. Div., Engelhard Industries Inc., Mass (o,dd,ee)
McCarter Iron Works, Inc., Pa (o,z,bb,cc)
McInnes Steel Co., Pa (o)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Michigan Seamless Tube Co., Mich (ee)
Midvale-Heppenstall Co., Pa (w)
Mott Metallurgical Corp., Ill
(porous)—Ad p 466
Murray, A.B. Co., Inc., NJ (ee)
National Electric Div., H.K. Porter Co., Inc., Pa (ee)
National Supply Co., Pa (o,q,w)
National Tube Div., U.S. Steel Corp., Pa (ee)
National-Standard Co., Mich
(dd,ff)—Ad p 421
New Jersey Metals Co., NJ (w)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb,ee)
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa (ff)
Pencoyd Steel & Forge Corp., Pa (o,q,w)
Precision Tube Co., Inc., Pa (ee)
Purdy, A.R. Co., Inc., NJ (o,z,bb,cc,dd,ff)
Rathbone Corp., Mass (o,bb)
Republic Steel Corp., Ohio
(o,q,w,z,bb,cc,dd,ee,ff)—Ad pp 84-85
Reynolds Aluminum Supply Co., Ga (o,z,bb,cc,dd,ee)
Riverside-Alloy Metal Div., H.K. Porter Co., Inc., NJ
(bb,dd,ff)—Ad p 160
Rodney Metals, Inc., Mass (v,dd)
Rolled Alloys, Inc., Mich (o,q,z,bb,cc,dd,ee,ff)
Rome Mfg. Div., Revere Copper & Brass Inc., NY (ee)
Ross-Meehan Foundries, Tenn (o)
Ryerson, Joseph T. & Son, Inc., Ill (o,q,z,bb,cc,dd,ee,ff)
St. Louis Steel Casting, Inc., Mo (n)
Sandusky Foundry & Machine Co., Ohio (ee)
Sandvik Steel, Inc., NJ
(dd,ee,ff)—Ad p 83
Service Steel Div., Van Pelt Corp., Mich (ee)
Seymour Mfg. Co., Conn (dd)
Sharon Steel Corp., Pa (q,w,z,cc,dd)
Sharpsville Steel Fabricators, Inc., Pa (o,z,bb,cc)
Sherwatt Equipment & Mfg. Co., Inc., NY (ff)
Simonds Saw & Steel Co., Mass (o,cc)
Smith-Moon Steel Co., Kan (o,z,cc,dd)
Solar Steel Corp., Ohio (o,z)
Somers Brass Co., Inc., Conn
(v,dd,)—Ad p 162
Stainless and Strip Div., Jones & Laughlin Steel Corp., Mich
(o,q,w,bb,cc,dd,ff)—Ad pp 96-97

Stainless and Strip Div., Jones & Laughlin Steel Corp., Ohio (dd)—Ad p 89
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa (q,w)
Star Heel Plate Co., Inc., NJ (z,ff)
Sun Steel Co., Ill (cc,dd)
Superior Drawn Steel Co., Pa (o, bb,ff)
Superior Mfg. Co., Pa (dd,ff)
Superior Steel Corp., Pa (dd)
Superior Steel Div., Copperweld Steel Co., Pa (dd)
Superior Tube Co., Pa (ee)
Sylvania Electric Products, Inc., Parts Div., Pa (ff)
Techalloy Co., Inc., Pa (v,bb,dd,ff)
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (o,q,w,z,cc,dd,ff)
Timken Roller Bearing Co., Steel & Tube Div., Ohio (o,q,ee)
Trent Tube Co., Sub. of Crucible Steel Co. of America, Pa (ee)
Tube Distributors Co., Inc., NY (ee)
Tube Reducing Corp., NJ (ee)
Uddeholm Co. of America, Inc., NY (bb,dd)
Ulbrich Stainless Steels Corp., Conn (dd)
Ullmann, Inc., Wis (o,ee)
Union Steel Corp., NJ (dd,ee)
United Screw & Bolt Corp., Ill (bb, cc,dd,ff)
U.S. Challenge & Challenge Co., Ill (bb)
U.S. Gasket & Shim Co., Ohio (cc,dd)
U. S. Steel Corp., Pa (o,q,w,z,cc,dd, ee)
U.S. Steel Supply Div., U.S. Steel Corp., Ill (o,q,z,cc,ee)
Universal-Cyclops Steel Corp., Pa (o, q,z,bb,cc,dd,ff)
Uniworld Research Corp. of America, Ohio (o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Vanadium Corp. of America, NY —Ad p 86
Vanadium-Alloys Steel Co., Pa (o,q,w, z,aa,bb,cc,ff)
Vulcan Rail & Construction Co., NY (o,dd,ee)
Vulcan-Kidd Steel Div., H.K. Porter Co., Inc., Pa (o,q,z,bb,ff)
Waimet Alloys Co., Mich (w)—Ad p 82
Wall Tube & Metal Products Co., Tenn (ee)
Wallingford Steel Co. Conn (v,dd)
Washington Steel Corp., Pa (cc,dd)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,w,z,bb,cc,dd,ee)
Whitehead Metal Products Co., Inc., NY (z,bb,cc,dd)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (z)
Wisconsin Centrifugal Foundry Inc., Wis (ee)
Worcester Wire Works Div., National-Standard Co, Mass (ff)

Steel, Heat and Corrosion Resistant—Castings

Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa
Adirondack Steel Casting Co., NY
Aelco Foundries, Inc., Wis
Allegheny Ludlum Steel Corp., Pa
All-Metals Precision Casting Corp., NY
Alloy Engineering & Casting Co., Ill
Alloy Precision Castings Co., Ohio
Alloy Steel Casting Co., Pa
American Brake Shoe Co., NY
American Cast Iron Pipe Co., Ala
American Steel Foundries, Ill
Apex Steel Corp., Ltd., Calif
Arwood Corp., NY
Austenal Co., Div. of Howe Sound Co., NY
Baldwin-Lima-Hamilton Corp., Pa
Beaver Valley Alloy Foundry Co., Pa
Beloit Foundry Co., Ill
Bethlehem Steel Co., Pa
Blaw-Knox Co., Pa
Bone Engineering Corp., Calif
Bonney-Floyd Co., Ohio
Brinkerhoff Brass & Bronze Works, Inc., NY
Calorizing Co., Pa
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich
Carondelet Foundry Co., Mo
Commercial Steel Casting Co., Ohio
Copper Alloy Corp., NJ
Crucible Steel Casting Co., Pa
Curtiss-Wright Corp., Metals Processing Div., NY
Dodge Steel Co., Pa
Donegal Steel Foundry Co., Pa
Duraloy Co., Pa
Duriron Co., Inc., Ohio
Electric Steel Foundry Co., Ore
Electro-Alloys Div., American Brake Shoe Co., Ohio
Empire Steel Castings, Inc., Pa
Engineered Castings Div., American Brake Shoe Co., NY
Fahralloy Co., Ill
Fort Pitt Steel Casting Div., Pittsburgh Steel Foundry Corp., Pa
Frasse, Peter A. & Co., Inc., NY
General Alloys Co., Mass
General Electric Co., Foundry Dept., NY
General Electric Co., Metallurgical Products Dept., Mich
Goslin Birmingham Mfg. Co., Inc., Ala.
Grede Foundries, Inc., Wis
Hanford Foundry Co., Calif
Hartford Electric Steel Corp., Conn
Hica, Inc., La
Hitchiner Mfg. Co., Inc., NH
Howard Foundry Co., Ill
Humphrey Castings, Inc., Calif
Illinois Precise Casting Co., Ill
Industrial Stainless Steels, Inc., Mass
Ingersoll-Rand Co., NJ
Janney Cylinder Co., Pa
Johnson, A. & Co., Inc., NY
Jones & Laughlin Steel Corp., Strip Steel Div., Ohio (dd)
Kay-Brunner Steel Products, Inc., Calif
Kolcast Industries Div., Thompson Products, Inc., Ohio
LFM Mfg. Co., Inc., Sub. of Rockwell Mfg. Co., Kan
Lebanon Steel Foundry, Pa
Los Angeles Steel Casting Co., Calif
Manco Products, Inc., Mich
Massillon Steel Casting Co., Ohio
Michigan Steel Casting Co., Div. of Consolidated Foundries & Mfg. Corp., Mich
Midwest Precision Castings Co., Ohio
Minneapolis Electric Steel Castings Co., Minn.
Misco Precision Casting Co., Mich
National Malleable & Steel Castings Co., Ohio
National Precision Casting Corp., Div. of Beryllium Corp., Pa
National Supply Co., Pa
Ohio Steel Foundry Co., Ohio
Oklahoma Steel Castings Div., American Steel & Pump Corp., Okla.
Perfecto Cast, Calif
Picco, Inc., Calif
Pittsburgh Steel Foundry Corp., Pa
Precision Founders, Inc., Calif
Quaker Alloy Casting Co., Pa
Rockwell Engineering Co., Ill
Ross-Meehan Foundries, Tenn
Ryerson, Joseph T. & Son, Inc., Ill
St. Louis Steel Casting, Inc., Mo
Sandusky Foundry & Machine Co., Ohio
Sharpsville Steel Fabricators, Inc., Pa
Sivyer Steel Casting Co., Wis
Skookum Co., Inc., Ore
Sherwatt Equipment & Mfg. Co., Inc., NY (ff)
Stainless Foundry & Engineering, Inc., Wis
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa
Stanwood Corp., Ill
Star Heel Plate Co., Inc., NJ
Superior Foundry, Inc., Ohio
Symington-Gould Corp., NY
Texas Foundries, Inc., Tex
Texas Steel Co., Tex.
Thompson Products, Inc., Valve Div., Ohio
Union Iron Works, Wash
U.S. Magnet & Alloy Corp., NJ —Ad p 420
U.S. Pipe & Foundry Co., Ala
Unicast Corp., Ohio —Ad p 467
Uniworld Research Corp. of America, Ohio
Utility Steel Foundry, Calif
Vollrath Co., Contract Div., Wis
Wall Colmonoy Corp., Stainless Process Div., Mich
West Steel Casting Co., Ohio
Westinghouse Electric Corp., Materials Mfg. Dept., Pa
Wisconsin Centrifugal Foundry, Inc., Wis

Steel, Low Alloy

Acme Tube, Inc., NJ (ee)
Acme-Newport Steel Co., Ky (z,cc,ee)
Advance Screw Products Co., Inc., Wis
Advance Stamping Co., Mich (dd)
Alan Wood Steel Co., Pa (z,cc,dd)
Alco Products, Inc., NY (q,aa)
Allegheny Ludlum Steel Co., Pa (o,q,w,z,bb,cc,dd,ee,ff)—Ad p 87
Alloy Metal Products, Inc., Iowa (o, q,w)
Alofs Mfg. Co., Mich (cc,dd,ff)
Amalgamated Steel Corp., Ohio (o, bb)
American Cast Iron Pipe Co., Ala (ee)
American Steel & Wire Div., U.S. Steel Corp., Ohio (o,dd)—Ad pp 90-91
Anchor Drawn Steel Co., Div. of Vanadium-Alloys Steel Co., Pa (bb, ff)
Arcos Corp., Pa (ff)
Aristoloy Steel, Div., Copperweld Steel Co., Ohio (o,q)
Armco Steel Corp., Ohio (z,cc,dd)
Armco Steel Corp., Sheffield Div., Mo (o,q,w,z,bb,cc,ff)
Arrow Metal Products Corp., NJ (cc)
Atlantic Steel Co., Ga (o)
Austenal Co., Div. of Howe Sound Co.,
Babcock & Wilcox Co., Tubular Products Div., Pa (ee)
Bethlehem Steel Co., Pa (o,q,z,bb,cc, dd,ee,ff)
Biddle Screw Products Co., Ind (o,bb, ee)
Bliss & Laughlin, Inc., Ill (o)
Burkhardt Steel Co., Colo (o,z,cc,dd)
Byers, A.M. Co., Pa (o,q,w,z)
California Metal Enameling Co., Calif (cc)
Cannon-Muskegon Corp., Mich (w)
Carpenter Steel Co., Pa (o,q,w,bb,dd, ff)
Castle, A.M. & Co., Ill (o,q)
Colonial Steel Div., Vanadium-Alloys Steel Co., Pa (o,q,w,z,bb,cc,ff)
Columbia-Geneva Steel Div., U.S. Steel Corp., Calif (o,q,w,z,cc,dd,ee)
Connors Steel Div., H.K. Porter Co., Inc., Ala (o,q)
Crucible Steel Co. of America, Pa (o,q,w,z,bb,cc,dd,ee,ff)—Ad p 93
Crucible Steel Co. of America, Titanium & Vacuum Metals Product Div., Pa (o,q,w,bb,cc,dd)
Curtiss-Wright Corp., Metals Processing Div., NY (ee,ff)
Dixon Sintaloy, Inc., Conn (o)
Dudek & Bock Spring Mfg Co., Ill (dd,ff)
Eastern Rolling Mills, Inc., NY (cc,dd)
Empire-Reeves Steel Div., Universal-Cyclops Steel Corp., Pa (z,cc)
Enterprise Wheel & Car Corp., Va (z,cc)
Eynon-Dakin Co., Mich (ee)
Finkl, A. & Sons Co., Ill (w)
Frasse, Peter A. & Co., Inc., NY (o,z,bb,cc,dd,ee,ff)
Great Lakes Steel Corp., Div. of National Steel Corp., Mich (z,cc,dd)
Green River Steel Corp., Ky (o,q,w)
Hardy, Charles, Inc., N (aa)
Hayden Wire Works, Inc., Mass (o,bb, ff)
Haydon Corp., NY (ee)
Higbie Mfg. Co., Mich (ee)
Hoeganaes Sponge Iron Corp., N J (aa)—Ad p 462
Inland Steel Co., Ill (o,z,cc,dd)
Jones & Laughlin Steel Corp., Pa (o, q,z,bb,cc,dd,ee,ff)
Kaiser Steel Corp., Calif (o,q,w,z,bb, cc,dd)
Kelsey-Hayes Co., Mich (o,q,z,cc)
Keystone Drawn Steel Co., Pa (q)
Kinkead Industries, Inc., Ill (cc,dd)
Larson, Charles E. & Sons Inc., Ill (o)
La Salle Steel Co., Ill (o)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Latrobe Steel Co., Pa (o,q,w)—Ad p 95
LeTourneau, R.G., Inc., Tex (z)
Levinson Steel Co., Pa (cc)
Lincoln Steel Corp., Neb (cc)
Lukens Steel Co., Pa (w,z)
Lundquist Tool & Mfg. Co., Inc., Mass (cc,dd)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (o,dd,ee)
McInnes Steel Co., Pa (o)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Michigan Seamless Tube Co., Mich (ee)
Midvale-Heppenstall Co., Pa (w)
Murray, A.B. Co., Inc., NJ (ee)
National Tube Div., U.S. Steel Corp., Pa (ee)
National-Standard Co., Mich (ff)—Ad p 421
National-U.S. Radiator Corp., Plastic Metals Div., Pa (aa)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb)
Northwestern Steel & Wire Co., Ill (o,q,w,z,bb,ff)
Ohio Seamless Tube Div., Copperweld Steel Co., Ohio (ee)
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa (ff)
Pencoyd Steel & Forge Corp., Pa (o,q,w)
Peninsular Steel Co., Mich (o,q,z)
Pittsburgh Forgings Co., Mich (o,q)
Rathbone Corp., Mass (o,bb)
Reliance Div., Eaton Mfg. Co., Ohio (o,ff)
Republic Steel Corp., Ohio (o,q,w,z,bb,cc,dd,ee,ff)—Ad pp 82-83
Revere Copper & Brass, Inc., NY (ee)
Rome Mfg. Div., Revere Copper & Brass, Inc., NY (ee)
Ross-Meehan Foundries, Tenn (o)
Ryerson, Joseph T. & Son, Inc., Ill (o,z,bb,cc,dd)
St. Louis Steel Casting, Inc., Mo (n)
Sandusky Foundry & Machine Co., Ohio (ee)
Sandvik Steel, Inc., NJ (dd)—Ad p 83
Sawhill Tubular Products, Inc., Pa (ee)
Scudder, E.J. Foundry & Machine Co., NJ (bb,ee)
Service Steel Div., Van Pelt Corp., Mich (ee)
Sharon Steel Corp., Pa (q,w,z,cc,dd)
Sharpsville Steel Fabricators, Inc., Pa (o,z,bb,cc)
Simonds Saw & Steel Co., Mass (o,cc)
Smith-Moon Steel Co., Inc., Kan (o,z,cc)
Solar Steel Corp., Ohio (o,z)
Stainless and Strip Div., Jones & Loughlin Steel Corp., Ohio (dd)—Ad p 89
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa (q,w)
Star Heel Plate Co., Inc., NJ (ee,ff)
Sun Steel Co., Ill (o,q,z,bb,cc,dd)
Superior Drawn Steel Co., Pa (o,bb,ff)
Superior Tube Co., Pa (ee)
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (o,q,w,z,cc,dd,ee)
Thomas Strip Div., Pittsburgh Steel Co., Pa (dd)
Thompson Wire Co., Mass (dd)
Timken Roller Bearing Co., Steel & Tube Div., Ohio (o,q,ee)
Tube Distributors Co., Inc., NY (ee)
Tube Reducing Corp., NJ (ee)
Uddeholm Co. of America, Inc., NY (bb)
Ullmann, Inc., Wis (o,ee)
Union Iron Works, Wash (cc)
Union Steel Corp., NJ (dd)
United Screw & Bolt Corp., Ill (bb,cc,dd,ff)
U. S. Steel Corp., Pa (o,q,w,z,cc,dd)—Ad pp 84-85
U.S. Steel Supply Div., U.S. Steel Corp., Ill (o,z,cc,dd,ee)
Vanadium-Alloys Steel Co., Pa (o,q,w,z,aa,bb,cc,ff)
Washburn Wire Co., Phillipsdale Div., RI (q,bb,dd)
Weirton Steel Co., Div. of National Steel Corp., W.Va (cc)
Western Automatic Machine Screw Co., Div. of Standard Screw Co., Ohio (o)
Wheelock, Lovejoy & Co., Inc., Mass (o,q,bb)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (w,z)
Wilder Mfg. Co., Inc., Calif (o,z,cc)
Wyckoff Steel Co., Pa (o,z)
Youngstown Sheet and Tube Co., Ohio (o,z,cc,dd,ee)

Steel, Low Alloy —Castings

Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa
Adirondack Steel Casting Co., NY
Advance Foundry Co., Ohio
Allied Steel Castings Co., Ill
All-Metals Precision Casting Corp., NY
Alloy Cast Steel Co., Ohio
Alloy Precision Castings Co., Ohio
Alloy Steel & Metals Co., Calif
American Cast Iron Pipe Co., Ala
American Manganese Steel Div., American Brake Shoe Co., Ill
American Steel Foundries, Ill
Arwood Corp., NY
Atlantic Foundry Co., Ohio
Atlantic Steel Castings Co., Pa
Austenal Co., Div. of Howe Sound Co., NY
Auto Specialties Mfg. Co., Mich
Baldwin-Lima-Hamilton Corp., Pa
Bay City Electric Steel Casting Co., Mich
Beaver Valley Alloy Foundry Co., Pa
Bethlehem Steel Co., Pa
Birdsboro Steel Foundry & Machine Co., Pa
Blaw-Knox Co., Pa
Bone Engineering Corp., Calif
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich
Carondelet Foundry Co., Mo
Commercial Steel Casting Co., Ohio
Crucible Steel Casting Co., Pa
Dayton Steel Foundry Co., Ohio
Dodge Steel Co., Pa
Electric Steel Castings Co., Ind
Electric Steel Foundry Co., Ore
Electrocast Steel Foundry Co., Ill
Empire Foundry Co., Inc., Calif
Empire Steel Castings, Inc., Pa
Federal Steel Products Corp., Tex
General Electric Co., Foundry Dept., NY
General Steel Castings Corp., Ill
Glover Machine Works, Ga
Goslin Birmingham Mfg. Co., Inc., Ala
Grafton Foundry Co., Wis
Grede Foundries, Inc., Wis
Gunite Foundries Corp., Ill
Hartford Electric Steel Corp., Conn
Hica, Inc., La
Hitchiner Mfg. Co., Inc., NH
Howard Foundry Co., Ill
Hughes Tool Co., Tex
Humphrey Castings, Inc., Calif
Illinois Precise Casting Co., Ill
Kay-Brunner Steel Products, Inc., Calif
Kolcast Industries Div., Thompson Products, Inc., Ohio
Lebanon Steel Foundry, Pa
Lectromelt Casting Div., Akron Standard Mold Co., Ohio
Los Angeles Steel Casting Co., Calif
Mackintosh-Hemphill Div., E.W. Bliss Co., Pa
Massillon Steel Casting Co., Ohio
Mercast Mfg. Corp., Calif
Metropolitan Iron Foundry, NY
Midwest Precision Castings Co., Ohio
Minneapolis Electric Steel Castings Co., Minn
Misco Precision Casting Co., Mich
Missouri Steel Castings Co., Mo
Monroe Steel Castings Co., Mich
National Malleable & Steel Castings Co., Ohio
National Precision Casting Corp., Div. of Beryllium Corp., Pa
National Supply Co., Pa
Ohio Steel Foundry Co., Ohio
Oklahoma Steel Castings Div., American Steel & Pump Corp., Okla
Olympic Steel Works, Wash
Omaha Steel Works, Neb
Pelton Steel Casting Co., Wis
Picco, Inc., Calif
Pittsburgh Steel Foundry Corp., Pa
Posey Iron Works Inc., Pa
Pratt & Letchworth Div., Dayton Malleable Iron Co., Inc., NY
Precision Founders, Inc., Calif
Quaker Alloy Casting Co., Pa
Quality Electric Steel Castings, Inc., Tex
Racine Steel Castings Co., Belle City Malleable Div., Wis
Reliance Steel Castings Co., Pa
Rockwell Engineering Co., Ill
Ross-Meehan Foundries, Tenn
Ryerson, Joseph T. & Son, Inc., Ill
St. Louis Steel Casting, Inc., Mo
Sandusky Foundry & Machine Co., Ohio
Sawbrook Steel Castings Co., Ohio
Scudder, E.J. Foundry & Machine Co., NJ
Sharpsville Steel Fabricators, Inc., Pa
Sivyer Steel Casting Co., Wis
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa
Star Heel Plate Co., Inc., NJ
Strong Steel Foundry Co., NY
Superior Foundry, Inc., Ohio
Swedish Crucible Steel Co., Mich
Taylor-Wharton Co., Div. of Harsco Corp., NJ
Texas Foundries, Inc., Tex
Texas Steel Co., Tex
Union Iron Works, Wash
Union Spring & Mfg. Co., Pa
Unitcast Corp., Ohio —Ad p 467
United Shoe Machinery Corp., Mass
U. S. Magnet & Alloy Corp., NJ
U.S. Pipe & Foundry Co., Ala
Utility Steel Foundry, Calif
Valley Steel Casting Co., Mich
Vulcan Iron Works, Pa
Washington Iron Works, Wash
West Steel Casting Co., Ohio
Westinghouse Electric Corp., Materials Mfg. Dept., Pa
Westlectric Castings, Inc., Calif
Worthington Corp., NJ

Steel, Specialty

(electrical, magnet, nitriding, etc.)

Acme-Newport Steel Co., Ky (cc)
Adirondack Steel Casting Co., NY
Allegheny Ludlum Steel Corp., Pa (o,q,z,bb,ff)—Ad p 87
Alloy Metal Powders, Inc., NY (aa)
Amalgamated Steel Corp., Ohio (o,bb)
American Silver Co., Inc., NY (v, bb, ee,ff)
Armco Steel Corp., Ohio (o,q,v,z,bb,cc,dd,ee,ff)
Arnold Engineering Co., Ill (dd)
Atlantic Steel Co., Ga (o)
Austenal Co., Div. of Howe Sound Co., NY (w)
Bethlehem Steel Co., Pa (o,q)
Biddle Screw Products Co., Ind (o,bb,ee)
Brush Beryllium Co., Ohio (v,dd)
Byers, A. M. Co., Pa (q,z)
Cannon-Muskegon Corp., Mich (w,ff)
Carpenter Steel Co., Pa (o,q,w,bb,dd,ee)
Chicago Development Corp., Md (aa)
Colonial Steel Div., Vanadium-Alloys Steel Co., Pa (o,q,w,z,bb,cc,ff)
Crucible Steel Co. of America, Pa (o,q,w,z,bb,cc)
Crucible Steel Co. of America, Titanium & Vacuum Metal Products Div., Pa (o,q,z,bb,cc,dd,ff)
Edgcomb Steel & Aluminum Corp., NJ (o,cc,dd)
Firth Sterling Inc., Pa (o,q,w,bb,ff)
Green River Steel Corp., Ky (o,q,w)
Hamilton Watch Co., Precision Metals Div., Pa (v,cc,dd,ff)
Hoeganaes Sponge Iron Corp., NJ (aa)—Ad p 462
Inland Steel Co., Ill (cc)
Johnston & Funk Titanium Corp., Ohio (w,bb,ff)
Jones & Laughlin Steel Corp., Pa (o,z,cc)
Kassel Export Co., Inc., NJ (dd,ff)
Kelsey-Hayes Co., Metals Div., NY (o,q,w,z,bb,cc,dd,ff)
Larson Tool & Stamping Co., Mass (o)
La Salle Steel Co., Mo (o)
Latrobe Steel Co., Pa (o,q,w)
Lukens Steel Co., Pa (w,z)
Manganese Steel Forge Co., Pa (o,z,bb,cc,dd,ff)
McInnes Steel Co., Pa (o)
Midvale-Heppenstall Co., Pa (q,w)
National Supply Co., Pa (o,q,w)
National-Standard Co., Mich (dd,ff)
Reactive Metals, Inc., Ohio (cc)
Republic Steel Corp., Ohio (o,q,w,z,bb,cc,dd,ee)
Ryerson, Joseph T. & Son, Inc., Ill (o)
Sandvik Steel, Inc., NJ (a,bb,dd)—Ad p 83
Sharon Steel Corp., Pa (cc)
Simonds Saw and Steel Co., Mass (cc,dd)
Stauffer-Temescal Co., Calif (o,q,w,z,bb,cc,dd,ff)
Stulz-Sickles Co., NJ (o,q,z,bb)
Superior Steel Corp., Pa (dd)
Sylvania Electric Products Inc., Parts Div., Pa (ff)
Timken Roller Bearing Co., Steel & Tube Div., Ohio (o,q,ee)
Ullmann, Inc., Wis (o,ee)
Universal-Cyclops Steel Corp., Pa (o,q,z,bb,cc,dd,ff)
Vanadium-Alloys Steel Co., Pa (o,q,w,z,aa,bb,cc,ff)
Vascoloy-Ramet Corp., Ill
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb,cc,dd,ee)

Steel, Specialty —Castings

Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa
Allegheny Ludlum Steel Corp., Pa
All-Metals Precision Casting Corp., NY
Alloy Precision Castings Co., Ohio
American Brake Shoe Co., NY
American Steel Foundries, Ill
Arwood Corp., NY
Austenal Co., Div. of Howe Sound Co., NY
Baldwin-Lima-Hamilton Corp., Pa
Beaver Valley Alloy Foundry Co., Pa
Bethlehem Steel Co., Pa
Blaw-Knox Co., Pa
Bone Engineering Corp., Calif
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich
Carondelet Foundry Co., Mo
Crobalt, Inc., Mich
Crucible Steel Casting Co., Pa
Curtiss-Wright Corp., Metals Processing Div., NY
Electric Steel Foundry Co., Ore
General Electric Co., Foundry Dept., NY
General Steel Castings Corp., Ill
Grede Foundries, Inc., Wis
Hica, Inc., La
Howard Foundry Co., Ill.

Humphrey Castings, Inc., Calif
Janney Cylinder Co., Pa
Johnston & Funk Titanium Corp., Ohio
Kay-Brunner Steel Products, Inc., Calif
Kolcast Industries, Div., Thompson Products, Inc., Ohio
LFM Mfg. Co., Sub. of Rockwell Mfg. Co., Kan
Lebanon Steel Foundry, Pa
Los Angeles Steel Casting Co., Calif
Manco Products, Inc., Mich
Mercast Mfg. Corp., Calif
Midwest Precision Castings Co., Ohio
Misco Precision Casting Co., Mich
Missouri Steel Castings Co., Mo
National Precision Casting Corp., Div. of Beryllium Corp., Pa
National Supply Co., Pa
Ohio Steel Foundry Co., Ohio
Overmyer Mould Co., Inc., Ind
Perfecto Cast, Calif
Picco, Inc., Calif
Precision Founders, Inc., Calif
Quaker Alloy Casting Co., Pa
Quality Electric Steel Castings, Inc., Tex
Rockwell Engineering Co., Ill
Ryerson, Joseph T. & Son, Inc., Ill
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa
Star Heel Plate Co., Inc., NJ
Stulz-Sickles Co., NJ
Swedish Crucible Steel Co., Mich
Taylor-Wharton Co., Div. of Harsco Corp., NJ
Texas Foundries, Inc., Tex
United Shoe Machinery Corp., Mass
U.S. Magnet & Alloy Corp., NJ
U.S. Pipe & Foundry Co., Ala
Uniworld Research Corp. of America, Ohio
Utility Steel Foundry, Calif
Vanadium-Alloys Steel Co., Pa
Wall Colmonoy Corp., Stainless Process Div., Mich
Washington Iron Works, Wash
West Steel Casting Co., Ohio
Westinghouse Electric Corp., Materials Mfg. Dept., Pa
Wisconsin Centrifugal Foundry, Inc., Wis

Steel, Tool and Die

Able Tool & Engineering Co., Ill (z)
Advance Stamping Co., Mich (o,z,bb)
Albraco Metals Corp., NY (o,q,bb)
Allegheny Ludlum Steel Corp., Pa
(o,q,z,bb,ff)—Ad p 87
Alofs Mfg. Co., Mich (o,z,bb)
Amalgamated Steel Corp., Ohio (o,bb)
American Brake Shoe Co., NY (aa)
Anchor Drawn Steel Co., Div. of Vanadium Alloys Steel Co., Pa (bb,ff)
Austenal Co., Div. of Howe Sound Co., NY (w)
Bethlehem Steel Co., Pa (o,q)
Biddle Screw Products Co., Ind (o,bb,ee)
Braeburn Alloy Steel Corp., Pa (o,q)
Cannon-Muskegon Corp., Mich (w)
Carpenter Steel Co., Pa (o,q,w,bb,dd,ff)
Columbia Tool Steel Co., Ill (o,q,w,bb)
Crucible Steel Co. of America, Pa
(o,q,w,z,bb,cc)—Ad p 93
Crucible Steel Co. of America, Titanium & Vacuum Metal Products Div., Pa (o,q,w,z,bb,cc,dd,ff)
Delaware Tool Steel Corp., Del (o)
Edgcomb Steel & Aluminum Corp., NJ (o,q,w,bb)
Finkl, A. & Sons Co., Ill (w)
Firth Sterling, Inc., Pa (o,q,w,bb,ff)
Forg, Peter Mfg. Co., Mass (cc)
Frasse, Peter A. & Co., Inc., NY (o)
Green River Steel Corp., Ky (o,q,w)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (o,z,bb)
Heller Tool Co., Ohio (o)
Inshield Die & Stamping Co., Ohio (o)
Jessup Steel Co., Pa (o,q,z,cc,dd)
Jones & Laughlin Steel Corp., Pa (o,z,bb)
Kinkead Industries, Inc., Ill (o,z,bb)
Larson, Charles E. & Sons, Inc., Ill (o)
Latrobe Steel Co., Pa
(o,q,w)—Ad p 95
Lundquist Tool & Mfg. Co., Inc., Mass (o,z,bb)
Midvale-Heppenstall Co., Pa (q,w)
Morrisville Foundry Co., Inc., Vt (bb)
National Supply Co., Pa (o,q,w)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb,ee)
Norwalk Powdered Metals, Inc., Conn (aa)
Ormond Mfg., Co., Inc., NJ (cc,dd,ff)
Pencoyd Steel & Forge Corp., Pa (o,q,w)
Peninsular Steel Co., Mich (o,q,z)
Pittsburgh Tool Steel Wire Co., Pa (o,bb)
Republic Steel Corp., Ohio (o,q)
Ross-Meehan Foundries, Tenn (o)
Ryerson, Joseph T. & Son, Inc., Ill (o,bb,cc)
Simonds Saw & Steel Co., Mass (o,cc)
Solar Steel Corp., Ohio (o,bb)
Superior Tube Co., Pa (ee)
Timken Roller Bearing Co., Steel & Tube Div., Ohio (o,q)
Uddeholm Co. of America, Inc., NY (o,q)
q,z,bb,cc,dd,ff)
Universal-Cyclops Steel Corp., Pa (o,
Vanadium-Alloys Steel Co., Pa (o,q,w,z,aa,bb,cc,ff)
Vulcan-Kidd Steel Div., H.K. Porter Co. Inc., Pa (o,q,w,bb,ff)
Waimet Alloys Co., Mich
(w)—Ad p 82
Wheelock, Lovejoy & Co., Inc., Mass (o,q,bb)
Wilder Mfg. Co., Inc., Calif (o,bb)
Ziv Steel & Wire Co., Ill (o,q)

Steel, Tool and Die —Castings

Albraco Metals Corp., NY
Allegheny Ludlum Steel Corp., Pa
All-Metals Precision Casting Corp., NY
Alloy Precision Casting Co., Ohio
American Foundry & Machine Div., Eimco Corp., Utah
Apex Steel Corp., Ltd., Calif
Arwood Corp., NY
Atlantic Steel Castings Co., Pa
Austenal Co., Div of Howe Sound Co., NY
Bay City Electric Steel Casting Co., Mich
Beaver Valley Alloy Foundry Co., Pa
Bone Engineering Corp., Calif
Carondelet Foundry Co., Mo
Crucible Steel Co. of America, Pa
Crucible Steel Casting Co., Pa
Curtiss-Wright Corp., Metals Processing Div., NY
Empire Steel Castings, Inc., Pa
General Electric Co., Foundry Dept., NY
Hica, Inc., La
Hitchiner Mfg. Co., Inc., NH
Howard Foundry Co., Ill
Illinois Precise Casting Co., Ill
Kolcast Industries Div., Thompson Products Inc., Ohio
LFM Mfg. Co., Sub. of Rockwell Mfg. Co., Kan
Lebanon Steel Foundry, Pa
Manco Products, Inc., Mich
Midwest Precision Castings Co., Ohio
Misco Precision Casting Co., Mich
Missouri Steel Castings Co., Mo
National Precision Casting Corp., Div. of Beryllium Corp., Pa
National Supply Co., Pa
Precision Founders, Inc., Calif
Quaker Alloy Casting Co., Pa
Rockwell Engineering Co., Ill
Ross-Meehan Foundries, Tenn
Star Heel Plate Co., Inc., NJ
Swedish Crucible Steel Co., Mich
Vanadium-Alloys Steel Co., Pa
Westinghouse Electric Corp., Materials Mfg. Dept., Pa

Strip

(see specific material)

Strippable Coatings

(see Organic Coatings)

Styrene

(see Polystyrene)

Styrene-Butadiene Rubber

Adhesive Products Corp., NY (x)
American Hard Rubber Co., Div. of Amerace Corp., NJ (bb,cc,dd,ee)
American Synthetic Rubber Corp., NY (p)
Anderson Assoc., Inc., Ohio (y)
Auburn Plastics, Inc., NY (bb,cc,dd)
Auburn Rubber Co., Inc., Ind (cc)
Automotive Rubber Co., Inc., Mich (cc,dd)
Belko Corp., Md (y)
Bond International, Inc., Mich (y,ee)
Borden Co., Borden Chemical Div., NY (p)
Capac Mfg. Corp., Mich (y,cc)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chicago-Allis Mfg. Corp., Ill (p)
Continental Rubber Works, Pa (bb,cc,dd,ee)
Copolymer Rubber and Chemical Corp., La (p)
Dayton Rubber Co., Ohio (y,bb,cc,dd,ee)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
Dyna-Therm Chemical Corp., Calif (p)
Electrofilm, Inc., Calif (t)
Faultless Rubber Co., Ohio (u,y,bb,ee)
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass (u,y,cc,ee)
Firestone Tire & Rubber Co., Ohio (p)
Garlock Packing Co., NY (y,bb,cc,dd,ee)
Geauga Industries Co., Ohio (y,bb,dd)
General Tire & Rubber Co., Chemical Div., Ohio (p)
Goodrich, B.F. Chemical Co., Ohio (p,cc)
Goodrich-Gulf Chemicals Inc., Ohio (p)
Goodyear Tire & Rubber Co., Chemical Div., Ohio (p)
Goshen Rubber Co., Inc., Ind
(y)—Ad p 438
Heresite & Chemical Co., Wis (p)
Hewitt-Robins, Inc., Conn (cc,ee)
Home Rubber Co., NJ (y,bb,cc,dd)
Koppers Co., Inc., Pa (p)
Maloney, F.H. Co., Tex (y)
Marbon Chemical Div., Borg-Warner Corp., Ind (p,u,x,y)
Martin Rubber Co., Inc., NJ (y,dd,ee)
Mid-States Rubber Products, Inc., Ind (y)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (p,u,x,y)
Paeco Rubber Co., Inc., Ohio (y,dd,ee)
Parker Seal Co., Div. of Parker-Hannifin Corp., Calif (u)
Parker, Stearns & Co., Inc., NY (cc,dd)
Phillips Chemical Co., Okla (p)
Polymer Chemical Co., Ohio (x)
Republic Rubber Div., Lee Rubber & Tire Corp., Ohio (p,y,cc,dd,ee)
Roberts Toledo Rubber Co., Ohio (ee)
Roth Rubber Co., Ill (y,cc)
Rubatex Div., Great American Industries Inc., Va (u)
Rubber Corp. of America, NY (m)
Shell Chemical Co., NY (p)
Sheller Mfg. Corp., Mich (u)
Southern Plastics Co., SC (bb,cc,dd,ee)
Stockwell Rubber Co., Inc., Pa (y,bb,cc,dd)
Technical Specialties Co., NY (dd)
Texas-U.S. Chemical Co., Tex (p)
Toyad Corp., Pa
(u)—Ad p 260
Trostel, Albert Packing, Ltd., Wis (y)
United Rubber & Chemical Co., Tex (p)
U.S. Rubber Co., NY (p)
U.S. Rubber Co., Kem-Blo Dept., Conn
(u)—Ad p 250
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (p,y,cc)
Vulcanized Rubber & Plastics Co., Pa (y)

KEY

MATERIALS

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b—Copper and its alloys
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l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
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r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Western Felt Works, Ill (y,cc,dd,ee)
Westlake Plastics Co., Pa (t,bb,cc, dd)
Williams-Bowman Rubber Co., Ill (y, bb,cc)

Superalloys

(see Nickel; Cobalt; Chromium)

Synthetic Fibers

(see specific polymer)

Tantalum and its Alloys

Alpha Metals, Inc., NJ (v,cc,dd)
American Silver Co., NY (v,dd,ee,ff)
Belmont Smelting & Refining Works, Inc., NY (aa)
Bishop, J. & Co. Platinum Works, Pa (ee)
Bridgeport Brass Co., Conn (ee)
Damascus Tube Co., Pa (ee)
Fansteel Metallurgical Corp., Ill
(n,o,q,v,w,z,aa,bb,cc,dd,ee,ff) — Ad p 174
Firth Sterling Inc., Pa (q,aa)
Foote Mineral Co., Pa (aa)
Hamilton Watch Co., Precision Metals Div., Pa (v,dd)
Hardy, Charles, Inc., NY (aa)
Harvey Aluminum, Calif (o,bb)
Haynes Stellite Co., Div. of Union Carbide Corp., Ind (o,bb,cc,dd,ee,ff)
Hoskins Mfg. Co., Mich (ff)
Johnston & Funk Titanium Corp., Ohio (bb,ff)
Kawecki Chemical Co., NY (n,o,q,v, w,z,aa,bb,cc,dd,ee,ff)
Kennametal, Inc., Pa
(o,v,aa,dd,ff)—Ad p 306
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (dd)
Mallory-Schwarzkopf Metals, Inc., NY (o,v,w,z,bb,cc,dd,ee,ff)
National Research Corp., Mass (v, w,aa,bb,cc,ee,ff)
Nuclear Metals, Inc., Mass (w,bb,dd, ee)
Oregon Metallurgical Corp., Ore (w)
Rodney Metals, Inc., Mass (v,dd)
Shieldalloy Corp., NJ (aa)
Stauffer-Temescal Co., Calif (o,q,v,w, z,bb,cc,dd,ee,ff)
Superior Tube Co., Pa
(ee)—Ad pp 414-415
Texas Instruments, Inc., Metals & Controls Div., Mass (v,dd,ff)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY
(w,aa)—Ad p 181
Universal Cyclops Steel Corp., Pa (o, q,z,cc)
Wah Chang Corp., NY
(v,aa,bb,dd,ff)—Ad p 164
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb, cc,dd,ee)

Tapes, Adhesive

American Tape Co., Mich
Armstrong Cork Co., Pa
Avery Label Co., Decorative Products Div., Ohio
Angier Adhesives Div., Interchemical Corp., Mass
Atlantic Bag Co., NY
Beck, I. & Sons, Inc., NY
Coating Products, Inc., NJ
—Ad p 359
Connecticut Hard Rubber Co., Conn
Cycleweld Div., Chrysler Corp., Mich
Durable Rubber Products Co., Ill
Dutch Brand Div., Johns-Manville Corp., Ill
Electro Technical Div., Sun Chemical Corp., NJ
Enflo Corp., NJ
Foamade Industries, Mich
Foss Mfg. Co., Id
Hampton Mfg. Co., NY
Hiller Aircraft Corp., Adhesive Engineering Div., Calif
Insulation Mfrs. Corp., Ill
Interchemical Corp., NY
Interchemical Corp., Finishes Div., NJ
Johns-Manville Corp., NY
Kinkead Industries, Inc., Ill
Lundquist Tool & Mfg. Co., Inc., Mass
Magnesium Co. of America, Ind
Moxness Products, Inc., Wis
—Ad p 460
Mystik Adhesive Products, Inc., Ill
Narmco Industries, Inc., Narmco Materials Div., Calif
Nicolet Industries, Inc., NY
Permacel, NJ
Presstite Div., American-Marietta Co., Mo
Respro Div., General Tire & Rubber Co., RI
Reynolds Aluminum Supply Co., Ga
Rubber & Plastics Compound Co., Inc., NY
Superior Plastics, Inc., Ill
Technical Tape Corp., NY

Teflon

(see Fluorocarbons)

Terne Plate

(see Precoated Metals)

Tetrafluoroethylene

(see Fluorocarbon)

Tin and Its Alloys

African Metals Corp., NY (w)
Allied Research Products, Inc., Md (n)
Alpha Metals, Inc., NJ (n,o,q,v,w,aa, bb,cc,dd)
American Metal Climax, Inc., NY (w,aa)
American Smelting & Refining Co., NY (n,o,w)
Anchor Metal Co., Inc., NY (w,aa)
Arcos Corp., Pa (ff)
Belmont Smelting & Refining Works, Inc., NY (n,o,v,w,aa,cc,dd,ff)
Caspers Tin Plate Co., Ill (cc,dd)
Cerro de Pasco Sales Corp., NY
(w)—Ad p 178
Crown Metal Co., Wis (n,ee,ff)
Division Lead Co., Ill (o,v,w,cc,dd,ee, ff)
Dixon Sintaloy, Inc., Conn (o)
Empire Metal Co., NY (n,o,q,w,bb,ff)
Farrelloy Co., Pa (aa,ff)
Glidden Co., Chemical Divs., Metals Dept., Ind
(aa)—Ad p 429
Greenback Industries, Inc., Mich (aa)
Hardy, Charles, Inc., NY (aa)
Harshaw Chemical Co., Ohio (n)
Hayden Wire Works, Inc., Mass (ff)
Hi-Grade Alloy Corp., Ill (n,o,v,w,ee)
Hodgson Foundry Co., Ill (n)
Indium Corp. of America, NY (dd,ff)
Johnston Foil Div., Standard Packaging Corp., Mo (v,cc)
Korhumel Steel and Aluminum Co., Ill (z,dd)
McGean Chemical Co., Ohio (n,o,aa)
Metal & Thermit Corp., NJ (n,w,aa)
Metallizing Engineering Co., Inc., NY (ff)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Metals Disintegrating Co., Inc., NJ
(aa)—Ad p 456
Modern Plating Corp., Ill (n)
National Lead Co., NY (n,o,q,w,z,aa, bb,cc,dd,ee)
Nesor Alloy Products Co., NJ (ff)
Norwalk Powdered Metals, Inc., Conn (aa)
Pittsburgh Smelting & Refining Co., Pa (o,w)
Presswork, Inc., Mich (cc)
Republic Metals Co., Inc., NY (n,o, v,w,cc,ee,ff)
Revere Copper & Brass, Inc., NY (v)
Revere Copper & Brass, Inc., Foil Div., NY (v)
River Smelting & Refining Co., Ohio (o)
Rotometals, Calif (o,v,w,aa)
Sall, George Metals Co., Inc., Pa (w)
Sherwatt Equipment & Mfg. Co., Inc., NY (ff)
Stevens, Frederic B., Inc., Mich (n)
Udylite Corp., Mich (n)
United Refining & Smelting Co., Ill (n,o,q,w,z,bb,cc,dd,ff)

Tinplate

(see Precoated Metals)

Titanium and Its Alloys

Alpha Metals, Inc., NJ (v)
American Silver Co., NY (v,dd,ee,ff)
Belmont Smelting & Refining Works, Inc., NY (aa)
Bishop, J. & Co. Platinum Works, Pa (ee)
Bridgeport Brass Co., Conn (ee)
Central Fabricators, Inc., Ohio (z,bb, cc,ee)
Chicago Development Corp., Md (o,v,z, aa,bb,cc,dd,ff)
Crucible Steel Co. of America, Pa
(o,q,w,z,bb,cc,dd,ee,ff)—Ad p 93
Crucible Steel Co. of America, Titanium & Vacuum Metal Products Div., Pa (o,q,v,z,bb,cc,dd,ee,ff)
Damascus Tube Co., Pa (ee)
Driver-Harris Co., NJ (v,dd)
du Pont de Nemours, E. I. & Co., Inc., Del (w)
Electric Steel Foundry Co., Ore (o, q,w,bb,ee)
Foote Mineral Co., Pa (o,bb)
General Electric Co., Metallurgical Products Dept., Mich (q,w,aa,bb,cc, dd)
Hardy, Charles, Inc., NY (aa)
Harvey Aluminum, Calif (o,q,w,bb,ee)
Hexcel Products, Inc., Calif (v)
Hoskins Mfg. Co., Mich (ff)
Johnston & Funk Titanium Corp., Ohio (bb,ff)
Kennametal, Inc., Pa (aa,bb,ee)
King Laboratories, Inc., NY (w,aa)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (o,dd)
Mallory, P.R. & Co., Inc., Ind (o,v, bb,cc,dd,ee)
Metal Forming Corp. Div., Vanadium-Alloys Steel Co., Ind (ee)
Metal Hydrides, Inc., Mass (aa)
Metal & Thermit Corp., NJ (w)
Metals Disintegrating Co., Inc., NJ (aa)
Michigan Seamless Tube Co., Mich (ee)
National Lead Co., NY (o,q,w,z,bb,cc, dd,ee,ff)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Nuclear Metals, Inc., Mass (w,bb,dd, ee)
Oregon Metallurgical Corp., Ore (w,ee)
Pioneer Aluminum, Inc., Calif (z)
Reactive Metals, Inc., Ohio (o,q,w,z, bb,cc,dd,ee,ff)
Republic Steel Corp., Ohio
(o,q,v,w,z,aa,cc,dd,ee,ff) — Ad pp 84-85
Rigidized Metals Corp., NY (cc,dd)
Superior Steel Corp., Pa (dd)
Superior Tube Co., Pa (ee)
Techalloy Co., Inc., Pa (dd,ff)
Texas Instruments, Inc., Metals & Controls Div., Mass (v,cc,dd)
Titanium Metals Corp. of America, NY
(o,q,v,z,aa,bb,cc,dd,ee,ff)
Trent Tube Co., Sub. of Crucible Steel Co. of America, Pa (ee)
Tube Distributors Co., Inc., NY (ee)
Tube Reducing Corp., NJ (ee)
Ulimann, Inc., Wis (o,ee)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
United International Research, Inc., NY (aa)
Vanadium Corp. of America, NY (w)
Worcester Wire Works Div., National-Standard Co., Mass (ff)
Youngstown Welding & Engineering Co., Ohio (ee)

Tool Steels

(see Steel)

Transfer Moldings

(see Moldings)

Trifluorochloroethylene

(see Fluorocarbon)

Tubing, Pipe

Ace Plastic Co., NY (k,l)
Acme Tube, Inc., NJ (a,b)
Acme-Newport Steel Co., Ky (g)
Aerojet-General Corp., Structural Materials Div., Calif (l)
Albert Pipe Supply Co., Inc., NY (a,g,k)
Albright Son & Co., Pa (g)
Allegheny Ludlum Steel Corp., Pa (g)
Allied Tube Corp., Pa (a,g)
Aluminum Co. of America, Pa (a,e)
Amco Plastic Pipe Co., Calif (k)
American Agile Corp., Ohio (k)
American Brass Co., Sub. of Anaconda Co., NY (b)
American Cast Iron Pipe Co., Ala
(c,f,g)—Ad p 410
American Metal Products Co., Mich (a,g)
American Molding Co., Calif (k)
American Nickel Alloy Mfg. Corp., NY (f)
American Pipe & Construction Co., Ore (g)
American Plastics Corp., NY (k)
American Reed Co., Inc., Mass (a)
American Smelting & Refining Co., NY (d)
American Silver Co., NY (b,f,g,h)
Ampco Metal, Inc., Wis (b)
Anaconda Metal Hose Div., American Brass Co., Sub. of Anaconda Co., Conn (a,b,g,k)
Anchor Plastics Corp., NY (k)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Armco Steel Corp., Ohio (g)
Arvin Industries, Inc., Ohio (a,g)
Atlantic India Rubber Works, Inc., Ill (m)
Atlantic Steel Co., Ga (a,g)
Atlas Mineral Products Co., Pa (k)
Auburn Plastic Engineering, Ill (k)
Avins Industrial Products Corp., NY (c)
Avon Tube Div., Higbie Mfg. Co., Mich (g)
Babcock & Wilcox Co., Tubular Products Div., Pa (g)

Badger Aluminum Extrusions, NY (a)
Barium Steel Corp., NY (g)
Benada Aluminum Products Co., Ohio (a)
Bethlehem Steel Co., Pa (g)
Bishop, J. & Co. Platinum Works, Pa (f,g)
Bohn Aluminum & Brass Corp., Mich (a)
Bond International, Inc., Mich (y,ee)
Borden Co., Borden Chemical Div., NY (k)
Brainard Steel Div., Sharon Steel Corp., Ohio (g)
Bridgeport Brass Co., Conn (a,b,f,h)—Ad p 176
Brinkerhoff Brass & Bronze Works, Inc., NY (a,b,f,g)
Broadway Mfg. Co., Wis (c,f,g)
Bundy Tubing Co., Mich (f,g)
Bunker Hill Co., Calif (d)
Burkhardt Steel Co., Colo (g)
Busada Mfg. Co., NY (c,g)—Ad p 442
Byers, A. M. Co., Pa (c,k)
Cadillac Plastic & Chemical Co., Mich (k,l,m)
Calfibe Co., Inc., Calif (k)
Carlon Products Corp., Ohio (k)
Carolina Industrial Plastics Div., Essex Wire Corp., NC (k)
Carpenter Steel Co., Pa (f,g,h)
Carpenter Steel Co., Alloy Tube Div., NJ (g)
Cartwright, R. Tube Products Co., Mich (a,b,e,f,g)
Celluplastic Corp., NJ (k)
Channel Master Corp., NY (a)
Chase Brass & Copper Co., Sub. of Kennecott Copper Corp., Conn (b)
Chicago Gasket Co., Ill (k)
Clayton Mark & Co., Ill (g)
Cleveland Steel Specialty Co., Inc., Ohio (g)
Clifton Conduit Corp., Md (g)
Colonial Alloys Co., Pa (a)
Colonial Plastics Mfg. Co., Div. of Van Dorn Iron Works Co., Ohio (k)
Colorado Fuel and Iron Corp., Colo (g)
Columbia-Geneva Steel Div., U. S. Steel Corp., Calif (g)
Conneaut Rubber & Plastics Co., Div. of U.S. Stoneware Co., Ohio (k,m)
Continental Copper & Steel Industries, Inc., NY (a,b,c,e,f,g,h)
Continental Rubber Works, Pa (m)
Continuous Cast Products Dept., American Smelting & Refining Co., NJ (b)
Copper and Brass Sales, Inc., Mich (a,b,e)
Cornell and Underhill, Inc., NJ (a,c,g)
Corson Industries, Pa (a)
Crane Co., Ill (k)
Crane Plastics, Inc., Ohio (k,m)
Crescent Plastics, Inc., Ind (k)
Crucible Steel Co. of America, Pa (f,g,h)
Crucible Steel Co. of America, Titanium & Vacuum Metals Products Div., Pa (f,g,h)
CrystalX Corp., Pa (k)
Curbell, Inc., NY (k,l,m)
Curtiss-Wright Corp., Metals Processing Div., NY (g,h)
Damascus Tube Co., Pa (f,g,h)
Daubert Chemical Co., Ill (m)
Defiance Metal Products Co., Ohio (g)
Detroit Floar & Stamping Co., Mich (b)
Division Lead Co., Ill (d)
Dixie Aluminum Corp., Ga (a)
Dixie Plastics Mfg. Co., La (k)
Dixon Corp., RI (k)
Dormont Mfg. Co., Pa (a,b,c,e)
Dow Chemical Co., Dow Metal Products Co. Div., Mich (e)
Drawn Metal Tube Co., Conn (b)
Dryden Rubber Div., Sheller Mfg. Co., Ill (m)
Easton Plastic Products Co., Inc., Pa (k)
Eclipse Plastic Industries, Inc., Fla (k)
Edgcomb Steel & Aluminum Corp., NJ (a)
Electric Steel Foundry Co., Ore (g,h)
Electronic Parts Mfg. Co., Inc., NJ (b,f)
Ellwood City Iron & Wire Co., Pa (c)
Emerson-Sack-Warner Corp., Mass (a, b,f,g)
Empire Metal Co., NY (d)
Ethylene Chemical Corp., NJ (l)
Evans Metal Co., Ga (d)
Eynon-Dakin Co., Mich (a,b,c,f,g)
Fibercast Co., Div. of Youngstown Sheet and Tube Co., Okla (l)
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass (m)
FitzSimons Mfg. Co., Mich (g)
Flexaust Co., Div. of Callahan Mining Co., Inc., NY (m)
Flexonics Corp., Ill (g)
Florence Pipe Foundry & Machine Co., NJ (c)
Formed Tubes, Inc., Mich (g)
Fox Products Co., Pa (a)
Franklin Plastics, Inc., Pa (k)
Frasse, Peter A. & Co., Inc., NY (a,g)
Fromson Orban Co., Inc., NY (a,b,f,g)
Fry Plastics International, Calif (k)
Garlock Packing Co., NY (k)
Gates Rubber Co., Colo (k)
Geauga Industries Co., Ohio (m)
General American Transportation Corp., Plastics Div., Ill
General Extrusions, Inc., Ohio (a)
General Motors Corp., Rochester Products Div., NY (g)—Ad p 435
Genesee Laboratories, Inc., NY (k)
Gering Plastics, Div. of Studebaker-Packard Corp., NJ (k)
Glass Laboratories, NY (k)
Goodrich, B.F., Industrial Products Co., Ohio (k)
H & H Tube & Mfg. Co., Mich (b)
H-P Products, Inc., Ohio (g)
Hall Mfg. Co., NJ (k)
Hartwell, H.N. & Son, Inc., Mass (k)
Harvey Aluminum, Calif (a,h)
Hawkridge Bros. Co., Mass (a)
Haydon Corp., NY (a,g)
Haynes Stellite Co., Div. of Union Carbide Corp., Ind (f)
Hays Mfg. Co., Pa (l)
Hazledine, E.T. Co., Ind (g)
Heil Process Equipment Corp., Ohio (k)
Hi-Grade Alloy Corp., Ill (d)
Houston Blow Pipe & Sheet Metal Works, Tex (a,b,g)
Hungerford Plastics Corp., NJ (k)
Hussey, C.G. & Co., Div. of Copper Range Co., Pa (b)—Ad p 180
Hydrawlik Co., NJ (k,m)
Imco Container Corp., Mo (k)
Industrial Pipe & Supply Co., Ill (g)
Industrial Plastic Fittings Co., Ohio (k)
Industrial Synthetics Corp., NJ (k)
International Nickel Co., Inc., NY (f)
Jackson Steel Products, Inc., NY (a, b,g)
Jarl Extrusions, Inc., NY (a)
Jessop Steel Co., Pa (g)
Jet Specialties Co., Inc., Calif (k)
Johnson Metal Hose, Inc., Conn (b,f)
Johnson Plastic Corp., Ohio (k,m)
Johnson Rubber Co., Ohio (m)
Jones & Laughlin Steel Corp., Pa (g)
Jordan-Rogers Co., Calif (k)
Judson Rubber Works, Inc., Ill (m)
K S H Plastics, Inc., Mo (k)
Kaiser Aluminum & Chemical Sales Inc., Ill (a)
Kaiser Steel Corp., Calif (g)
Kaufman Glass Co., Del (k,l)
Kenmore Machine Products, Inc., NY (b)
Kensico Tube Co., NY (b)
Kleiner Metal Specialties, Inc., NJ (g)
Koehler Mfg. Co., Mass (g)
Kraloy Plastic Pipe Co., Inc., Calif (k)
Laclede Steel Co., Mo (g)
Lamtex Industries, Inc., NY (l)
Langsenkamp, F.H. Co., Ind (a,b)
Leach & Garner Co., Mass (b,f)
Lee Rubber & Tire Corp., Pa (m)
Lewin-Mathes Co., Mo (b)
Lewis & Saunders, NH (a,b,g)
Linderme Tube Co., Ohio (a,b)
Lock Joint Tube Co., Inc., Ind (g)
Lunn Laminates, Inc., NY (l)
Lus-Trus Corp., Mich (k)
Luzerne Rubber Co., NJ (k,l)
MacKenzie-Walton Co., RI (b)
Magline Inc., Mich (a,e)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (a,b,e,g)
Manufacturers Corp., Ohio (k)
Manufacturers & Fabricators, Inc., Ohio (f)
Mechanical Rubber Products Co., NY (l)
Meier Screw Products & Mfg. Co., Mich (a,b,c,e,g)
Melco Wire Products, Calif (a)
Metal Forming Corp., Div. of Vanadium-Alloys Co., Ind (a,b,f,g)
Metal Goods Corp., Mo (a,b,f,g)
Midland Pipe & Supply Co., Ill (b,c,g)
Midvale-Heppenstall Co., Pa (g)
Minnesota Mining & Mfg. Co., Minn (k,l)
Missouri Boiler & Sheet Works, Mo (g)
Moore Drydock Co., Calif (g)
Morse, Fred W. Co., RI (a)
Moxness Products, Inc., Wis (m)
Mueller Brass Co., Mich (b)—Ad p 455
Murray, A.B. Co., Inc., NJ (a,b,f,g)
Naige Co., Inc., NY (k)
Narrangansett Boiler Works, Inc., RI (g)
National Copper & Smelting Co., Ohio (b)
National Electric Div., H.K. Porter Co., Pa (g)
National Galvanizing Co., Pa (g)
National Gasket & Washer Mfg. Co., Inc., NY (k,l,m)
National Lead Co., NY (a,b,d)
National Lead Construction Co., Inc., NJ (d)
National Supply Co., Pa (g)
National Tube Div., U.S. Steel Corp., Pa (g)
National Tube Div., U.S. Steel Corp., Pa (k)
National Vulcanized Fibre Co., Del (k,l)
New England Tape Co., Div. of United-Carr Fastener Corp., Mass (k)
Newage Industries, Inc., Pa (k)
Nikoh Tube Co., Ill (g)
Noera Mfg. Co., Conn (b,g)
Nuclear Metals, Inc., Mass (a,b,c,e, f,g,h)
Ohio Seamless Tube Div., Copperweld Steel Co., Ohio (g)
Ohio Steel Foundry Co., Ohio (f)
Olds Alloys Co., Calif (b,d,f)
Olin Mathieson Chemical Corp., Metals Div., NY (a)
Oregon Metallurgical Corp., Ore (h)
Pabst Engineering Equipment Co., Inc., NJ (a,b,c,e,f,g,h,j)
Panelyte Div., St. Regis Paper Co., NY (k,l)
Parker Metal Goods Co., Mass (a,g)
Parker, Stearns & Co., Inc., NY (m)
Parker-Street Castings Co., Ohio (c)
Pencoyd Steel & Forge Corp., Pa (c,g)
Penn Brass & Copper Co., Pa (b)
Penn Extrusion Corp., Pa (a)
Perfex Plastics, Inc., Ill (k)
Pfister Tubing Corp., NJ (a)
Philadelphia Bronze & Brass Corp., Pa (b)
Philrus Products Co., NJ (l)
Phoenix Iron & Steel Co., Pa (g)
Pittsburgh Steel Co., Pa (g)
Pittsburgh Tube Co., Pa (g)
Plastex Co., Ohio
Plastic Pipe & Tube Corp., Calif (k)
Plastic Process Co., Inc., Calif (k)
Plymouth Cordage Co., Mass (k)
Polyform Plastics Corp., NY (k)
Polymer Corp. of Pennsylvania, Sub. of Polymer Corp., Pa (k)
Porter, William Co., Calif (l)
Precision Extrusions, Inc., Ill (a)
Precision Tube Co., Inc., Pa (a,b,f,g)
Pressed Steel Co., Pa (f)
Prince Rubber Co., Inc., NY (k,l)
Pyramid Moldings, Inc., Ill (g)
Pyramid Plastics, Inc., Ill (k,m)
Raybestos-Manhattan, Inc., NJ (m)
Reading Tube Corp., NY (b)
Reflin Co., Calif (l)
Reinhold Engineering & Plastics Co., Calif (k)
Reliance Plastic & Chemical Corp., NJ (k)
Ren Plastics, Inc., Mich (l)
Replac Corp., Ohio (k,l,m)
Republic Steel Corp., Ohio (g)
Republic Steel Corp., Steel & Tubes Div., Ohio (f,g,h)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Resistoflex Corp., NJ (k)
Revere Copper & Brass, Inc., NY (a,b,g)
Reynolds Aluminum Supply Co., Ga (a,g,b)
Reynolds Metals Co., Va (a)
Rigidized Metals Corp., NY (a,g)
Rockwell Engineering Co., Ill (a,b,c,g)
Rolled Alloys, Inc., Mich (f,g)
Rolock, Inc., Conn (f)
Rome Mfg. Div., Revere Copper & Brass, Inc., NY (g)
Rome Turney Radiator Co., NY (a,b,g)
Roth Steel Products Co., Ohio (g)
Rotometals, Calif (d)
Rowland Products, Inc., Conn (k)
Ryerson, Joseph T. & Son, Inc., Ill (a,g)

Sandusky Foundry & Machine Co., Ohio (b,f,g)
Sandvik Steel, Inc., NJ (g)
Sanford Plastics Corp., NY (k)
Saran Lined Pipe Co., Div. of Michigan Pipe Co., Mich (g)
Sawhill Tubular Products, Inc., Pa (f,g)
Schwab Plastics Corp., Mich (k,m)
Scovill Mfg. Co., Mill Products Div., Conn (b)
Service Steel Co., Mich (g)
Shamban, W.S. & Co., Ind (k)
Shaw-Kendall Engineering Co., Ohio (a,b,c,f,g)
Sheffield Plastics Co., Mass (k)
Sheldon, M.L. & Co., Inc., NY (f)
Shenango Furnace Co., Centrifugally Cast Products Div., Ohio (b,c,f)
Shoe Form Co., DeWitt Plastics Div., NY (k)
Sierra Electric Corp., Calif (k)
Skyline Industries, Pa (k)
Small Tube Products, Inc., Conn (b)
Snyder, M.L. & Son, Inc., Pa (k)
Solar Steel Corp., Ohio (g)
South River Metal Products Co., Inc., NJ (a,e)
Southern Aluminum Finishing Co., Inc., Ga (a)
Southern Fabricating Co., Inc., Ala (g)
Southern Plastics Co., SC (k,m)
Southwestern Plastic Pipe Co., Tex (k)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (k)
Spiral-Glas Pipe Co., NJ (k,l,m)
Spuck Iron & Foundry Co., Mo (g)
Standard Metals Corp., Mass (b,f)
Standard Products Co., Mich (m)
Standard Tube Co., Mich (g)
Star Heel Plate Co., Inc., NJ (g)
Stockwell Rubber Co., Inc., Pa (k,m)
Stokes Molded Products, Div., Electric Storage Battery Co., NJ (k)
Summerill Tubing Co. Div., Columbia Steel & Shafting Co., Pa (g)
Sunlite Plastics, Inc., Wis (k)
Superior Tube Co., Pa
(c,f,g,h)—Ad pp 414-415
Supplex Co., Div. of Amerace Corp., NJ (k,m)
Surprenant Mfg. Co., Mass (k)
Swepco Tube Corp., NJ (f)
Synthane Corp., Pa (l)

Taunton Div., Haveg Industries, Inc., Mass (m)
Taylor Fibre Co., Pa (l)
Technical Specialties Co., NY (m)
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (g)
Texas Aluminum Co., Tex (a)
Thermoid Div., H. K. Porter Co., Pa (k,l,m)
Thompson Pipe & Steel Co., Colo (c,f,g)
Timken Roller Bearing Co., Ohio (g)
Titanium Metals Corp. of America, NY (h)
Tompkins Products, Mich (a)
Trent Tube Co., Sub. of Crucible Steel Co. of America, Pa (f,g,h)
Trenton Pipe Nipple Co., NJ (b,g)
Triangle Conduit & Cable Co., Inc., NJ (b,k)
Trim Alloys, Inc., Mass (a)
Tube Distributors Co., Inc., NY (c,e,f,g,h)
Tube Methods, Inc., Pa (c,f,g)
Tube Reducing Corp., NJ (f,g,h)
Tuff Clad, Inc., Ohio (k)

Udylite Corp., Mich (k)
Uniform Tubes, Inc., Pa (a,b,f,g)
Union Steel Corp., NJ (g)
U.S. Flexible Tubing Co., Ill (g)
U.S. Gasket Plastics Div., Garlock Packing Co., NJ (k,l)
U.S. Rubber Co., Mechanical Goods Div., Ind (k)
U.S. Steel Corp., Pa (g)
U.S. Steel Supply Div., U.S. Steel Corp., Ill (g)
U.S. Stoneware Co., Ohio (k)
U.S. Valve & Mfg. Co., Calif (g)
United Wire & Supply Corp., RI (a,b)
Universal Converting Corp., Mass (a)
Urrite Plastics Fabricators, Calif (k)

Vanadium-Alloys Steel Co., Pa (f,g)
Vanamatic Co., Ohio (g)
Van Huffel Tube Corp., Ohio (a,b,g)
Van Pelt Corp., Service Steel Div., Mich (f,g,h)
Viking Copper Tube Co., Ohio (b)
Viplax Products Corp., NJ (k)
Vogt Mfg. Corp., NY (k)
Vulcan Metal Products, Inc., Ala (a)
Vulcan Rail & Construction Co., NY (a,c,g)

Wall Tube & Metal Products Co., Tenn (b,f,g)
Wallace Tube Co., Div. of Wallace Supplies Mfg. Co. (a,b,g)
Wallingford Steel Co., Conn (g)
Wal-Mar Corp., Ill (a,b,c,e,g)
Waterman Industries, Inc., Calif (a,b)
Weiskittel, Harry C. Co., Inc., Md (c)
Welding Apparatus Co., Ill (a,f)
Wells, A.H. & Co., Inc., Conn (b)
Western Felt Works, Ill (l,m)
Western Textile Products Co., Mo (k,m)
Westlake Plastics Co., Pa (k,l,m)
Wheatland Tube Co., Pa (g)
Wheeling Steel Corp., Va (g)
White Metal Rolling & Stamping Corp., NY (a,e)
Whitehead Metal Products Co., Inc., NY (a,b,f,g)
William Brand-Rex Div., American Enka Corp., Mass (k)
Williams-Bowman Rubber Co., Ill
(l,m)—Ad p 276
Wolverine Tube Div., Calumet & Hecla, Inc., Mich
(a,b,g)—Ad p 445
Woolf Aircraft Products, Inc., Mich (a,b,f,g)
World Plastics, NY (k)

Yardley Plastics Co., Ohio (k)
Youngstown Mfg., Inc., Ohio (a)
Youngstown Sheet and Tube Co., Ohio (g)
Youngstown Welding & Engineering Co., Ohio (a,f,h)

Tungsten

American Metal Climax, Inc., NY (aa)
American Nickel Alloy Mfg. Corp., NY (w,aa)
Associated Engineering & Mfg. Corp., NJ (o,aa,bb,cc,dd,ff)
Belmont Smelting & Refining Works, NY (aa)
Cleveland Tungsten, Inc., Ohio (aa, bb)
Electronic Parts Mfg. Co., Inc., NJ (bb,cc,ee,ff)
Elmet Div., North American Philips Co. Inc., Me (o,w,aa,bb,ff)
Fansteel Metallurgical Corp., Ill
(n,o,q,v,w,z,aa,bb,cc,dd,ee,ff) — Ad p 174
Firth Sterling Inc., Pa (q,aa,bb)
Fromson Orban Co., Inc., NY (ff)
General Electric Co., Lamp Metals & Components Dept., Ohio (o,q,w, aa,bb,cc,dd,ff)
Gibson Electric Co., Pa
(aa)—Ad p 466
Hardy, Charles, Inc., NY (aa)
Harvey Aluminum, Calif (o,bb)
Hayden Wire Works, Inc., Mass (ff)
Kassel Export Co., Inc., NJ (v,bb, dd,ff)
Kennametal, Inc., Pa
(o,bb)—Ad p 306
Kinkead Industries, Inc., Ill (o)
Mallory-Schwarzkopf Metals, Inc., NY (o,v,w,z,bb,cc,dd,ee,ff)
Molybdenum Corp. of America, Pa (o, w,z,aa,bb,cc,dd)
Nuclear Metals, Inc., Mass (w,bb, dd,ff)
Oregon Metallurgical Corp., Ore (w)
Reduction & Refining Co., NJ (q,w,aa, bb,ff)
Shieldalloy Corp., NJ (aa)
Stauffer Chemical Co., NY
(q)—Ad p 163
Stauffer-Temescal Co., Calif (w)
Sylvania Electric Products, Inc., Chemical & Metallurgical Div., Pa
(w,aa,bb,ff)—Ad p 153
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
Universal-Cyclops Steel Corp., Pa (o, q,z,cc)
Wah Chang Corp., NY
(n,aa,bb,cc,ff)—Ad p 164
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb,cc, dd,ee)

Upset Forgings

(see Forgings)

Ureas

Adhesive Products Corp., NY (x)
Alcylite Plastics & Chemical Corp., Calif (p,x,y)
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY (p,y)
American Cyanamid Co., Plastics & Resins Div., NY
(p,u)—Ad pp 251-254
American Viscose Corp., Pa (y)
American-Marietta Co., Adhesive, Resin & Chemical Div., Wash (p)
Archer-Daniels-Midland Co., Minn (p)
Booty Resineers Div., American-Marietta Co., Ohio (p)
Borden Co., Borden Chemical Div., NY (p)
Catalin Corp. of America, NY (p,x)
Chemical Process Co., Calif (x)
Chemore Corp., NY (p,y)
Colton Chemical Co., Div. of Air Reduction Co., Inc., Ohio (u)
Dunnican Asso., NJ (y)
Dyna-Therm Chemical Corp., Calif (p)
Gordon Chemicals, Inc., Del (y)
Grigoleit Co., Ill (p,s)
Kurz Kasch, Inc., Ohio (y)
Luminous Resins, Inc., Ill (y)
Mica Insulator Div., Minnesota Minins & Mfg. Co., NY (bb,cc)
Monsanto Chemical Co., Plastics Div., Mass (p)
Muehlstein, H. & Co., Inc., NY (p,y)
Nopco Chemical Co., NJ (p)
Omni Products Corp., NY (p)
Reichhold Chemicals, Inc., NY (p,x)
Sierra Electric Corp., Calif (y)
Specialty Resins Co., Calif (p)
Sylvan Plastics, Inc., Pa (y)
Synco Resins, Inc., Conn (p)
Texas Glass Fiber Corp., Tex (y)

Urethane Elastomers

Acushnet Process Co., Mass (y)
Adhesive Products Corp., NY (x)
American Latex Products Co., Calif
American Rubber Products Corp., Ind (u,cc,dd)
B.B. Chemical Co., Bostik Dept., Mass (u)
Bond International, Inc., Mich (y,ee)
Brown Rubber Co., Inc., Ind (u)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chemical Coatings & Engineering Co., Inc., Pa (p,u,x,y)
Chicago-Allis Mfg. Corp., Ill (p)
Coast Pro-Seal & Mfg. Co., Calif (y)
Continental Rubber Works, Pa (bb,cc, dd,ee)
Dayton Rubber Co., Ohio (p,u,x,y,bb, cc,dd,ee)
Disogrin Industries, Inc., NY (bb,cc)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
du Pont de Nemours, E. I. & Co., Inc., Del (v)
Dyna-Therm Chemical Corp., Calif (p,x)
Faultless Rubber Co., Ohio (u)
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass (u)
Flexible Tubing Corp., Conn (ee)
Foam Products, Inc., Pa (u)
Foamade Industries, Mich (u,x,y,cc,dd)
General Electric Co., Plastics Dept., Ill (u)
General Plastics Mfg. Co., Wash (u,cc)
General Tire & Rubber Co., Chemical Div., Ohio (p)
Goodrich, B.F. Chemical Co., Ohio (p)
Hewitt-Robins, Inc., Conn (u,cc)
Hudson Cush-N-Foam Corp., NJ (u, bb,cc)
Isocyanate Products, Inc., Del (p,u)
Maco Industries, Inc., Ill (bb,cc,dd,ee)
Maloney, F.H. Co., Tex (x,y)
Marblette Corp., NY
Mobay Chemical Co., Pa (p,u,x,y)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (p,u,x,y)
Parker Seal Co., Div. of Parker-Hannifin Corp., Calif (u)
Pelron Corp., Ill (p,u,x,y)
Plas-Kem Corp., Div. of Dyna-Therm Chemical Corp., Calif (x)
Prince Rubber & Plastics Co., Inc., NY (bb)
Reynolds Chemical Products Co., Mich (p,u,x)
Schwab Plastics Corp., Mich (u)
Scott Paper Co., Foam Div., Pa (u)
Sheller Mfg. Corp., Mich (u)
Sterling Alderfer Co., Ohio (u,dd)
Stockwell Rubber Co., Inc., Pa (u,cc)
Taunton Div., Haveg Industries, Inc., Mass (u)
Technical Specialties Co., NY (dd)
Thermoid Div., H. K. Porter Co., Pa (u)
Thiokol Chemical Corp., NJ (p,y)
Thombert, Inc., Iowa (bb,cc)
Toyad Corp., Pa (t,u)
Trostel, Albert Packing, Ltd., Wis (y)
United Shoe Machinery Corp., Mass (p,u)
U.S. Rubber Co., NY (p)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (p,y,cc)
Western Felt Works, Ill (y,cc,dd,ee)
Witco Chemical Co., Ill (p,u)

Urethane Foams

Adhesive Products Corp., NY (x)
Aerojet-General Corp., Structural Materials Div., Calif (u)
American Latex Products Corp., Calif
American Rubber Products Corp., Ind (u,cc,dd)
Aries Laboratories, Inc., Conn (u)
Atlas Mineral Products Co., Pa (u)
Atlas Powder Co., Del (u)
B.B. Chemical Co., Bostik Dept., Mass (u)
Burkart, F. Mfg. Co., Div. of Textron Inc., Mo (u)
Cadillac Plastic & Chemical Co., Mich (x,y,bb,cc,dd)
Carolina Industrial Plastics Div., Essex Wire Corp., NC (u)
Chemical Coatings & Engineering Co., Inc., Pa (p,u,x,y)
Columbus Coated Fabrics Corp., Ohio (u)

Crest Chemical Industries Corp., NY (u)
CrystalX Corp., Pa (u)
Dayton Rubber Co., Ohio (p,u,x,y,bb, cc,dd,ee)
Disogrin Industries, Inc., NY (bb,cc)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (u,y)
du Pont de Nemours, E. I. & Co., Inc., Del (u)
Durez Plastics Div., Hooker Chemical Corp., NY (u)
Dyna-Therm Chemical Corp., Calif (p)
Electro Chemical Engineering & Mfg. Co., Pa (u, cc)
Englander Co., Inc., Industrial Products Div., Md (u)
Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Mass (u)
Foam Products, Inc., Pa (u)
Foamade Industries, Mich (u,x,y,cc,dd)
Foss Mfg. Co., Id (u)
Fry Plastics International, Calif (u)
Furane Plastics, Inc., Calif (x,y)
General Plastics Mfg. Co., Wash (u, cc)
General Tire & Rubber Co., Ind (u)
General Tire & Rubber Co., Chemical Div., Ohio (p)
Goodrich, B.F. Chemical Co., Sponge Products Div., Conn (u)
Hadley Bros.-Uhl Co., Mo (u)
Hewitt-Robins, Inc., Conn (u,cc)
Industrial Paint Div., Glidden Co., Ohio (p,u)
Interchemical Corp., Finishes Div., NJ (u)
Isocyanate Products, Inc., Del (p,u)
Luminous Resins, Inc., Ill (y)
Maco Industries, Inc., Ill (bb,cc,dd,ee)
Maloney, F.H. Co., Tex (y)
Marion Div., General Tire & Rubber Co., Ind (u)
Mobay Chemical Co., Pa (p,u,x,y)
Nesbitt Industries, Inc., Ill (u)
Nopco Chemical Co., NJ (u,cc)
Paeco Rubber Co., Inc., Ohio (y,dd, ee)
Pelron Corp., Ill (p,x,y)
Plas-Kem Corp., Div. of Dyna-Therm Corp., Calif (x)
Polytron Corp., Calif (p,u)
Quelcor, Inc., Pa (u)
Reichhold Chemicals, Inc., NY (u)
Richardson Co., NY (bb,cc,ee)
Russell Reinforced Plastics Corp., NY (u)
Schenectady Varnish Co., Inc., NY (p)
Schwab Plastic Corp., Mich (u)
Scott Paper Co., Foam Div., Pa (u)
Sheller Mfg. Corp., Mich (u)
Southern Plastics Co., NC (bb,cc,dd, ee)
Sterling Alderfer Co., Ohio (u,dd)
Strick Plastics Co., Pa (u)
Thiokol Chemical Corp., NJ (p,u,x,y)
Toyad Corp., Pa (u)—Ad p 260
United Shoe Machinery Corp., Mass (t,u)
U.S. Rubber Co., Conn (p,u,x,y)
William Brand-Rex Div., American Enka Corp., Mass (ee)
Witco Chemical Co., Ill (p,u)
Woodall Industries, Inc., Mich (u)

Vacuum Formed Parts

(see Moldings, Sheet)

Vacuum Metallizing

(see Metallized Coatings)

Vanadium

American Metal Climax, Inc., NY (o)
American Nickel Alloy Mfg. Corp., NY (w)
Belmont Smelting & Refining Works, Inc., NY (aa)
Bridgeport Brass Co., Conn (ee)
Chicago Development Corp., Md (aa)
Hardy, Charles, Inc., NY (aa)
Magnesium Elektron, Inc., NY (w,aa)
National-Standard Co., Mich (ff)—Ad p 421
Niagara Falls Smelting & Refining Div., **Continental Copper & Steel Industries, Inc., NY (v,w)**
Nuclear Metals, Inc., Mass (w,bb,ee)
Oregon Metallurgical Corp., Ore (v,w)
Shieldalloy Corp., NY (aa)
Texas Instruments, Inc., Metals & Controls Div., Mass (v)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (w,z,aa,bb)—Ad p 181
Vanadium Corp. of America, NY (o,v,z,bb,cc,dd,ee,ff)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb,cc,dd, ee)

Varnishes

(see Organic Coatings)

Vinyls

(Polyvinyl chloride and copolymers)
Adhesive Products Corp., NY (p,x,y)
Air Reduction Chemical Co., Div. of Air Reduction Co., Inc., NY (p)
Albany Novelty Mfg. Co., Mass (cc)
Albert Pipe Supply Co., Inc., NY (ee)
Alpha Plastics, Inc., NJ (bb,ee)
Alpha Wire Corp., NY (cc,ee)
Amercoat Corp., Calif (cc,ee)
American Hard Rubber Co., Div. of Amerace Corp., NJ (y,bb,cc,dd,ee)
American Products Mfg. Co., La (p,t, cc)
Atlas Mineral Products Co., Pa (cc,ee)
Auburn Plastics, Inc., NY (y,bb,cc,dd, ee)
Automotive Rubber Co., Inc., Mich (u,y,cc,dd)
Avery Label Co., Decorative Products Div., Ohio (u)
Blacher, B., NY (t)
Blossom Mfg. Co., NY (t,cc,dd)
Bolta Products Div., General Tire & Rubber Co., Mass (s,t,bb,cc,ee)
Borden Chemical Co., Div. of Borden Co., NY (p,ee)
Byers, A.M. Co., Pa (ee)
Cadillac Plastic & Chemical Co., Mich (t,cc,ee)
Carolina Industrial Plastics Div., Essex Wire Corp., NC (u,ee)
Carroll, J.B. Co., Ill (x,cc)
Chemical Products Corp., RI (u,y)
Chemore Corp., NY (p,s,y)
Colonial Plastics Mfg. Co., Div. of Van Dorn Iron Works, Ohio (bb,cc, dd,ee)
Columbus Coated Fabrics Corp., Ohio (t)
Comco Plastics, Inc., NY (cc,dd,ee)
Commercial Plastics & Supply Corp., NY (cc,ee)
Conneaut Rubber and Plastics Co., Div. of U.S. Stoneware Co., Ohio (t,bb,cc,dd,ee)
Cordo Chemical Corp., Conn (t,x,y)
Crane Plastics, Inc., Ohio (bb,dd,ee)
Crest Chemical Industries Corp., NY (u)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Curbell, Inc., NY (cc,ee)
Dennis Chemical Co., Mo (u,x,y)
Diamond Alkali Co., Ohio (p)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
Douglas & Sturgess, Calif (p,x,y)
Dow Chemical Co., Plastics Div., Mich (p)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
Dura Plastics of New York, Inc., NY (x,bb,cc,dd,ee)
Electric Steel Foundry Co., Ore (bb, cc,dd,ee)
Elm Coated Fabrics Co., Inc., NY (t,
Escambia Chemical Corp., NY (p)
Firestone Plastics Co., Pa (s,t)
Flexible Tubing Corp., Conn (ee)
Fry Plastics International, Calif (t, u,cc,dd,ee)
Galigher Co., Utah (bb,cc,dd,ee)
Geauga Industries Co., Ohio (p,bb,dd, ee)
General Tire & Rubber Co., Chemical Div., Ohio (p)
General Tire & Rubber Co., Textileather Div., Ohio (t)
Genesee Laboratory, Inc., NY (bb,dd, ee)
Gering Plastics Div., Studebaker-Packard Corp., NJ (y,bb,dd,ee)
Glass Laboratories, Inc., NY (dd)
Goodrich, B.F. Co., Sponge Products Div., Conn (u)
Goodrich Chemical Co., Ohio (p,u,x, y)
Goodrich, B.F. Industrial Products Co., Ohio (t,bb,cc,dd,ee)
Goodyear Tire & Rubber Co., Ohio (p,x)
Great American Industries, Inc., Rubatex Div., Va (u)
Hauger-Beegle Asso., Inc., Ill (t)
Heyden Newport Chemical Corp., American Plastics Corp. Div., NY (bb, ee)
Hydrawlik, NJ (bb,ee)
Industrial Plastics Corp., Ind (bb,dd, ee)
Insulation Mfrs. Corp., Ill (ee)
Interchemical Corp., Finishes Div., NJ (u)
K-S-H Plastics, Inc., Mo (bb,cc,dd, ee)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Kaykor Industries, Inc., Div. of Kaye-Tex Mfg. Corp., NJ (bb,cc,dd)
Kuss, R.L. & Co., Inc., Ohio (t, cc)
Lus-Trus Corp., Mich (bb,cc,dd,ee)
Mannesmann-Easton Plastic Products Co., Inc., Pa (bb,ee)
Masland Duraleather Co., Pa (t,cc)
Mayon Plastics, Minn (bb,ee)
Mono-Sol Corp., Ind (u)
Monsanto Chemical Co., Organic Chemicals Div., Mo (p)
Monsanto Chemical Co., Plastics Div., Mass (p,t,u,x,y,cc)
Morningstar-Paisley, Inc., NY (p)
Naige Co., Inc., NY (ee)
National Gasket & Washer Mfg. Co., Inc., NY (cc,dd,ee)
National Tube Div., U.S. Steel Corp., Pa (ee)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (p,u,x,y)
New England Tape Co., Div. of United-Carr Fastener Corp., Mass (bb,dd,ee)
Newage Industries, Inc., Pa (ee)
Nixon Nitration Works, NJ (cc)
O'Sullivan Rubber Corp., Va (t)
Pawling Rubber Corp., NY (bb,dd,ee)
Perfex Plastics, Inc., Ill (bb,dd,ee)
Plas Kem Corp., Div. of Dyna-Therm Chemical Corp., Calif (u,x,y)
Plast-Ad Mfg. Co., Ind (bb,cc,dd,ee)
Polo Plastics Co., Wis (t,u,cc)
Poly Resins, Calif (p,x)
Polymer Corp., Pa (p)
Premier Thermo Plastics Co., Ky (u, y)
Prince Rubber & Plastics Co., Inc., NY (bb,cc,dd,ee)
Pyramid Plastics, Inc., Ill (bb,dd,ee)
Pyrosil, Inc., Ohio (cc)
Quelcor, Inc., Pa (u,x,y,cc)
Reichhold Chemicals, Inc., NY (p)
Reliance Plastic & Chemical Corp., NJ (bb,cc,dd,ee)
Republic Rubber Div., Lee Rubber and Tire Corp., Ohio (dd,ee)
Reynolds Chemical Products Co., Mich (u,x,y)
Reynolds Metals Co., Va (t,x,cc)
Ross & Roberts, Inc., Conn (t,cc)
Rubber Corp. of America, NY (p,t,x, y,cc)
Rubber & Plastics Compound Co., Inc., NY (cc)
Scranton Plastic Laminating Corp., Pa (t,x,cc,dd)
Seaman Products, Calif (t)
Seiberling Rubber Co., Plastics Div., Ohio (t,u,cc)
Sheffield Plastics, Inc., Mass (ee)
Southern Plastics Co., SC (bb,cc,dd, ee)
Stockwell Rubber Co., Inc., Pa (bb, cc,ee)
Structural Products Div., National Starch & Chemical Corp., NY (p)
Sun Steel Co., Ill (t,x,cc,dd)
Sunlite Plastics, Inc., Wis (bb,dd,ee)
Superior Plastics, Inc., Ill (bb,cc,dd, ee)
Supplex Co., Div. of Amerace Corp., NJ (y,bb,dd,ee)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Taunton Div., Haveg Industries, Inc., Mass (ee)
Toyad Corp., Pa
(u)—Ad p 260
Tuff Clad, Inc., Ohio (x,cc)
Union Carbide Plastics Co., Div. of Union Carbide Corp., NY
(p,s,t,u,y,cc)—Ad p 257
U.S. Rubber Co., NY (p,y)
U.S. Stoneware Co., Ohio (bb,cc,dd,ee)
Varflex Corp., NY (ee)
Watson-Standard Co., Pa (u,y)
Western Textile Products Co., Mo (ee)
Whirlclad Div., Polymer Corp., Pa (p)
Whitehead Metal Products Co., Inc., NY (bb,cc,dd,ee)
William Brand-Rex Div., American Enka Corp., Mass (bb,dd,ee)

Vinyls

(Saran; polyvinyl alcohol, butyral and formal)
Air Reduction Chemical Co., Div. of Air Reduction Co., Inc., NY (p,s)
American Hard Rubber Co., Div. of Amerace Corp., NJ (bb,cc,dd,ee)
Automotive Rubber Co., Inc., Mich (cc,dd)
Avery Label Co., Decorative Products Div., Ohio (u)
Bolta Products Div., General Tire & Rubber Co., Mass (s)
Borden Chemical Co., Div. of Borden Co., NY (p)
Cadillac Plastic & Chemical Co., Mich (t)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
Dow Chemical Co., Plastics Div., Mich (p,t,y,bb,cc,dd,ee)
du Pont de Nemours, E. I. & Co., Inc., Del (p,t,x)
Franklin Glue Co., Ohio (p)
Fry Plastics International, Calif (t,u,cc,dd,ee)
Heyden Newport Chemical Corp., American Plastics Corp. Div., NY (bb,ee)
Kaufman Glass Co., Del (bb,cc,dd,ee)
Kuss, R. L. & Co., Inc., Ohio (s,t,cc)
Lus-Trus Corp., Mich (bb,dd,ee)
Mono-Sol Corp., Ind (t)
Monsanto Chemical Co., Plastics Div., Mass (t)
Plas Kem Corp., Div. of Dyna-Therm Corp., Calif (u,x,y)
Plast-Ad Mfg. Co., Ind (cc)
Prince Rubber & Plastics Co., Inc., NY (ee)
Pyramid Plastics, Inc., Ill (bb,cc,dd,ee)
Resistoflex Corp., NJ (cc,ee)
Reynolds Metals Co., Va (t,x,cc)
Saran Lined Pipe Co., Div. of Michigan Pipe Co., Mich (bb,cc,ee)
Seaman Products, Calif (t)
Shawinigan Resins Corp., Mass (p,y)
Stockwell Rubber Co., Inc., Pa (bb,cc,ee)
Structural Products Div., National Starch & Chemical Corp., NY (p)
Union Carbide Plastics Co., Div. of Union Carbide Corp., NY
(p)—Ad p 257
Whitehead Metal Products Co., Inc., NY (ee)

Vulcanized Fibre

Ace Plastic Co., NY (bb,cc)
Baer, N.S. Co., NJ (bb,cc,dd,ee)
Colonial Kolonite Co., Ill (bb,cc,ee)
Comco Plastics, Inc., NY (bb,cc,dd,ee)
Commercial Plastics & Supply Corp., NY (bb,cc)
Continental-Diamond Fibre Corp., Del (bb,cc,dd,ee)
Coyne & Paddock, Inc., NY (cc)
Curbell, Inc., NY (bb,cc,ee)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
Electrofilm, Inc., Calif (t)
Insulation Mfrs. Corp., Ill (bb,cc,dd,ee)
Iten Fibre Co., Ohio (s,bb,cc,dd,ee)
Laminated Plastex Corp., Ohio (x,cc)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
National Vulcanized Fibre Co., Del
(bb,cc,dd,ee)—Ad p 249
Penn Fibre & Specialty Co., Inc., Pa (bb,cc,dd,ee)
Philrus Products Co., NJ (bb,cc,dd,ee)
Spaulding Fibre Co., Inc., NY
(bb,cc,dd,ee)—Ad p 255
Staver Co., Inc., NY (cc,dd)
Taylor Fibre Co., Pa
(bb,cc,dd)—Ad p 246
Thombert, Inc., Iowa (cc,dd)
Westlake Plastics Co., Pa (bb,cc,dd,ee)
Wilmington Fibre Specialty Co., Del (bb,cc,dd,ee)

Welding Rods and Electrodes

(see Filler Metals)

Weldments

Abalon Precision Mfg. Corp., NY (a,b,c,g)
Acme Precision Products, Inc., Ohio (a,f,g)
Acorn Sheet Metal Mfg. Co., Inc., Ill (a,g)
Adams, I.G. Metalware Co., Mo (g)
Aerojet-General Corp., Structural Materials Div., Calif (a,b,c,d,e,f,g,h)
Albert Pipe Supply Co., Inc., NY (g)
Alco Products, Inc., NY (a,b,f,g)
Allis-Chalmers Mfg. Co., Wis. (a,f,g)
Alloy Products Corp., Wis (a,f,g,h)
Almco Steel Products Corp., Ind (a,b,c,g)
Aluminum Co. of America, Pa (a)
Amalgamated Steel Corp., Ohio (g)
American Brake Shoe Co., NY (b)
American Car & Foundry Div., ACF Industries, Inc., NY (a,e,g)
American Cast Iron Pipe Co., Ala (g)
American Machine & Foundry Co., Cleveland Welding Div., Ohio (a,c,f,g,h)
American Metal Products Co., Mich (a,g)
American Pipe & Construction Co., Ore (a,g)
American Sheet Metal Works, Inc., Conn (a,g)
American Welding and Mfg. Co., Ohio (a,f,g,h)
Ampco Metal, Inc., Wis (b)
Anderson, O.L. Co., Inc., Mich (a,b,c,d,g)
Armor Metal Products Co., Ohio (a,g)
Atlas Steel Construction Co., NY (a,b,c,g)
Automotive Rubber Co., Inc., Mich (a,c,e,g)
Baldwin-Lima-Hamilton Corp., Pa (a,g)
Barclay Mfg. Co., Ind (c)
Beatty Machine & Mfg. Co., Ind (g)
Behringer Metal Works, Inc., NJ (a,g)
Beloit Iron Works, Wis (c,g)
Bergen Point Iron Works, NY (a,b,c,f,g,h)
Bethlehem Steel Co., Pa (g)
Biersach & Niedermeyer Co., Wis (a,b,c,g)
Blaw-Knox Co., Pa (a,g)
Blickman, S. Inc., NJ (a,b,c,f,h)
Brandt, Charles T Inc., Md (a,b,e,f,g)
Brinkerhoff Brass & Bronze Works, Inc., NY (a,b,c,f,g)
Brooks & Perkins, Inc., Mich (a,e,g,h)—Ad p 457
Burkhardt Steel Co., Colo (c,g)
Butler Mfg. Co., Mo (a,g)
Caldwell, W.E. Co., Ky (a,g)
Central Fabricators, Inc., Ohio (a,b,c,f,g,h)
Clarksville Foundry & Machine Works, Tenn (a,c)
Cleveland Steel Specialty Co., Ohio (g)
Combined Industries Co., NY (a,b,c,e,f)
Combustion Engineering, Inc., Ill (a,b,g)
Commercial Shearing & Stamping Co., Ohio (g)
Continental Copper & Steel Industries Inc., NY (a,b,c,e,f,g,h)
Cornell and Underhill, Inc., NJ (a,g)
Darby Corp., Kan (a,f,g)
Dare Products, Inc., Mich (g)
Day Co., Minn (a,g)
Dixie Bronze Co., Ala (b)
Dolin Metal Products, Inc., NY (g)
Dow Chemical Co., Dow Metal Products Co. Div., Mich (e)
Downington Iron Works, Pa (c,g)
Dravo Corp., Pa (a,g)
Dresser Mfg. Div., Dresser Industries, Inc., Pa (g)
Electric Steel Foundry Co., Ore (g)
Emerson-Sack-Warner Corp., Mass (a,f,g)
Enterprise Wheel & Car Corp., Va (a,g)
Evans, George Corp., Ill (g)
Everard Tap & Die Corp., NY (a,g)
Falk Corp., Wis (g)
Falstrom Co., NJ (a,b,c,d,e,f,g,h,j)
Farwell Metal Fabricating, Minn (a,c,e,f,g)
Federal Machine and Welder Co., Ohio (g)
Fitzgibbons Boiler Co., Inc., NY (c)
Foster Wheeler Corp., NY (a,f,g)
Gary Steel Products Corp., Va (a,g)
General Alloys Co., Mass (a,b,f)
General American Transportation Corp., Ill (a,c,g)
General American Transportation Corp., Plate & Welding Div., Ill (a,c,g)
General Cable Corp., NY (g)
Glasby J.P. Mfg. Co., Inc., NJ (a,c,e,f,g)
Goslin Birmingham Mfg. Co., Inc., Ala (b,f,g)
Graver Tank & Mfg. Co. Div., Union Tank Car Co., Ind (a,f,g)
Greene, G.G. Corp., Pa (g)
Hardy, Mfg. Corp., Ind (g)
Hazledine, E.T. Co., Ind (g)
Hibben & Co., Ill (a,g)
Hicks Corp., Mass (a,b,g)
Hobbs, Clinton E. Co., Mass (c,g)
Houston Blow Pipe & Sheet Metal Works, Tex (a,b,g)
Ideal Can Co., Mass (a,c,g)
Indus Corp., Ind (a,g)
Industrial Equipment Co., Ohio (a,g)
Industrial Pipe & Supply Co., Ill (g)
Industrial Precision Products, Ill (a,c)
Ingalls Iron Works Co., Ala (c,g)
Ingersoll Products Div., Borg-Warner Corp., Ill (g)
Inland Mfg. Co., Neb (g)
Interlake Mfg. Co., Mich (g)
International Nickel Co., Inc., NY (f)
Irvington Form & Tank Corp., NY (a,b,g)
Irwin-Sensenich Corp., Pa (g)
Jervis Corp., Mich (a,g)
K-D Mfg. Co., Tex (c,g)
Kaiser Steel Corp., Calif (g)
Kelsey-Hayes Co., Mich (g)
Kewaunee Engineering Corp., Wis (c)
King, Alfred B. Co., Conn (a,b,c,d,f,g)
King Fifth Wheel Co., Pa (g)
Kirk & Blum Mfg. Co., Ohio (g)
Koven, L.O. & Bro., Inc., NJ (a,g)
Krueger Fabricating Co., Inc., Wis (a,b,c,e,g)
LFM Mfg. Co., Inc., Sub. of Rockwell Mfg. Co., Kan (g)
Langsenkamp, F.H. Co., Ind (a,b)
Larkin Specialty Mfg. Co., Calif (a,b,g)
Lawrence, L. Co., Inc., NJ (a,b,c,e,f,g,h,j)
Leader Iron Works, Inc., Ill (a,b,c,f,g)
Levinson Steel Co., Pa (g)
Lincoln Steel Corp., Neb (g)
Littleford Bros. Inc., Ohio (a,c,f,g)
Lockport Steel Fabricators, Inc., Ill (a,f,g)
Loeffler, J.M. Machine Co., Pa (a,b,c)
Lukens Steel Co., Pa (a,b,e,f,g,h)
Machine Products Corp., Ohio (a,b,c,f,g)
Magline, Inc., Mich (a,e)
Magnesium Co. of America, Ind (a,e)
Mahon, R.C. Co., Mich (a,g)
Manganese Steel Forge Co., Pa (g)
Manufacturers & Fabricators, Inc., Ohio (f,g)
Manufacturers Service, Inc., Ohio (a,b,g)
Mayville Metal Products Co., Wis (g)
McDowell-Wellman Cos., Ohio (g)
McGregor-Michigan Corp., Mich (c,f,g)
McLanahan & Stone Corp., Pa (g)
McNally Pittsburg Mfg. Co., Kan (a,c,g)
Midvale-Heppenstall Co., Pa (g)
Midwest Piping Co., Inc., Mich (g)
Missouri Boiler & Sheet Works, Mo (g)
Moore Dry Dock Co., Calif (g)
Morrisville Foundry Co., Inc., Vt (g)
Morse, Fred W. Co., RI (a,b,c,g,j)
Murray, A.B. Co., Inc., NJ (a,b,f,g)
Murray Tube Works Inc., NJ (g)
Narragansett Boiler Works, Inc., RI (g)
National Lead Construction Co., Inc., NJ (d)
National Metal Products Co., Pa (a,c,g)
National Screw & Mfg. Co., Ohio (g)
National Steel & Shipbuilding Corp., Calif (a,g)
National Tank Co., Okla (a,g)
Nigg Engineering Corp., Calif (a,c,g)
Olean Electro Plating Co., NY (g)
Pabst Engineering Equipment Co., Inc., NJ (a,c,f,g)
Parish Pressed Steel Div., Dana Corp., Pa (g)
Patterson Foundry & Machine Co., Ohio (a,g)
Pennsylvania Engineering Corp., Pa (g)
Penrod, Floyd & Sons Tool & Engineering Corp., Ind (g)
Pfaudler Co., NY (a,f,g)
Philadelphia Bronze & Brass Corp., Pa (b)
Phoenix Iron & Steel Co., Pa (g)
Portland Co., Me (a,f,g)
Posey Iron Works, Inc., Pa (g)
Pressed Steel Tank Co., Wis (a,f,g)
Progressive Service Co., Mo (g)
Pusey & Jones Corp., Del (a,b,c,e,f,g)
Queen Products Co., Inc., Ky (a,g)
Rankin Forge Co., Pa (c,g)
Republic Steel Corp., Ohio (g)
Reynolds Metals Co., Va (a)
Rockwell Engineering Co., Ill (a,b,c,g)
Rockwell-Standard Corp., Stamping Div., NY
(a,b,f,g)—Ad p 458
Rolock, Inc., Conn (f,g)
Rose Iron Works, Ohio (a,b,c,f,g,h)
Sandy Hill Iron & Brass Works, NY (b,g)
Scaife Co., Pa (a,b,c,f,g)
Seattle Boiler Works, Inc., Wash (a,f,g)
Shank Metal Products Co., NY (a,g)
Sherman & Reilly, Inc., Tenn (a,e,f,g)

Shriver, T. & Co., Inc., NJ (a,g)
Sinclair Co., Mass (b,c,g)
Sioux City Foundry & Boiler Co., Iowa (g)
Smith, A.O. Corp., Wis (a,g)
South River Metal Products Co., Inc., NJ (a,e,g)
Southern Car & Mfg. Co., Inc., Ala (a,g)
Southwestern Porcelain Steel Corp., Okla (g)
Spincraft, Inc., Wis (a,f,g)
Spring City Foundry Co., Pa (c)
Spuck Iron & Foundry Co., Mo (g)
Stacey Mfg. Co., Ohio (a,g)
Stainless Metals, Inc., NY (c,f,h)
Stalker Corp., Mich (f,g,h)
Standard Steel Sections, Inc., NY (a,c,g)
Stanwood Corp., Ill (g)
Star Heel Plate Co., Inc., NJ (g)
Steel, R. & Sons, Inc., NY (g)
Steel Fabricators Co., Ohio (a,c,e,f,g,h)
Stover Steel Tank & Mfg. Co., Ill (d,f,g)
Struthers Wells Corp., NY (a,f,g,h)
Sylvania Electric Products, Inc., Parts Div., Pa (b,c,f,g)
Texas Foundries, Inc., Tex (g)
Thompson Pipe & Steel Co., Colo (a,b,c,d,e,g,h)
Thys Co., Calif (g)
Toledo Stamping & Mfg. Co., Ohio (g)
Torngren, C.W. Co., Inc., Mass (a,b,c,f,g,h)
Trane Co., Wis (g)
Trojan Steel Co., W.Va (g)
Union Iron Works, Wash (g)
Union Tank Car Co., Ill (a,f,g)
United Shoe Machinery Corp., Mass (a,b,c,e,f,g)
U.S. Valve & Mfg. Co., Calif (g)
Variety Stamping Corp., Ohio (c,g)
Victor Steel Products Corp., NY (g)
Vulcan Mfg., Ohio (a,b,c,e,f,g,h)
Wal-Mar Corp., Ill (a,c,e,g)
Ward, H.H. Co., Pa (a,b,c,f,g,j)
Warren Brothers Roads Co., Mass (a,c,d,e,f,g,j)
Waterman Industries, Inc., Calif (a,g)
Werner, R.D. Co., Inc., NY
West Point Foundry & Machine Co., Ga (c)
Western Foundry & Machine Works, Inc., Kan (g)
Wheeler, C.H. Mfg. Co., Wheelerweld Div., Pa (b,c,f,g)
Whyte, Oliver Co., Inc., NY (a,c,g)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (a,b,c,f,g)
Wilder Mfg. Co., Inc., Calif (c,g)
Willamette Iron and Steel Co., Ore (f,g)
Wisconsin Centrifugal Foundry, Inc., Wis (b)
Woolf Aircraft Products, Inc., Mich (a,c,g)
Wyatt Metal & Boiler Works, Inc., Tex (a,b,c,e,f,g)
Youngstown Kitchens Div., American Standard Co., Ohio (a,g)
Youngstown Welding & Engineering Co., Ohio (a,f,h)

Wire

Abalon Precision Mfg. Corp., NY (a,b,c,g)
Ace Wire Spring & Form Co., Inc., Pa (g)
Acme Stamping & Wire Forming Co., Pa (a,b,g)
Acme Steel Products Div., Acme Steel Co., Ill (g)
Aerojet-General Corp., Structural Materials Div., Calif (g,h)
Alabama Wire Co., Inc., Ala (a)
Allegheny Ludlum Steel Corp., Pa (g)
All-State Welding Alloys Co., Inc., NY (a)
Almco Steel Products Corp., Ind (g)
Alofs Mfg. Co., Mich (a,g)
Alpha Wire Corp., NY (b)
Aluminum Co. of America, Pa (a)
American Chain & Cable Co., Pa (g)
American Electric Cable Co., Mass (b,c,g)
American Nickel Alloy Mfg. Corp., NY (f)
American Reed Co., Inc., Mass (c)
American Silver Co., NY (b,f,g,h)
American Smelting & Refining Co., NY
American Steel and Wire Div., U. S. Steel Corp., Ohio (b,g)
Anchor Drawn Steel Co., Div. of Vanadium-Alloys Steel Co., Pa (g)
Arcos Corp., Pa (a,b,e,f,h)
Armco Steel Corp., Ohio (g)
Associated Spring Corp., Wallace Barnes Steel Div. Conn (g)
Athenia Steel Div., National-Standard Co., NJ (g)
Atlantic Bag Co., NY (g)
Atlantic Steel Co., Ga (g)
Baker Platinum Div., Engelhard Industries, Inc., NJ (a,b,f,g,h)
Belmont Smelting & Refining Works, Inc., NY (d,j)
Beryllium Corp., Pa (b)
Bethlehem Steel Co., Pa (g)
Bishop, J. & Co. Platinum Works, Pa (f)
Bridgeport Brass Co., Conn (a,b,f)
Bristol Brass Corp., Conn (b)
Cambridge Wire Cloth Co., Md (a,b,c,e,f,g,h)
Carol Cable Co., Div. of Crescent Co., Inc., RI (b)
Carpenter Steel Co., Pa (g)
Carpenter Steel Co., Webb Wire Div., NJ (g)
Chase Brass & Copper Co., Sub. of Kennecott Copper Corp., Conn (a,b,f)
Chicago Development Corp., Md (h)
Ciendenin Bros., Inc., Md (a,b)
Colonial Alloys Co., Pa (a)
Colonial Steel Div., Vanadium-Alloys Steel Co., Pa (g)
Colorado Fuel and Iron Corp., Colo (g)
Colorado Fuel & Iron Corp., Pacific Coast Div., Calif (g)
Columbia-Geneva Steel Div., U.S. Steel Corp., Calif (b,g)
Comerford Mfg. Co., Inc., Conn (a,b,c,e,f,g,h,j)
Continental Steel Corp., Ind (g)
Copper and Brass Sales, Inc., Mich (a,b,e)
Crown Metal Co., Wis (d)
Crucible Steel Co. of America, Pa (f,g,h)
Crucible Steel Co. of America, Titanium & Vacuum Metal Products Div., Pa (h)
Curtiss-Wright Corp., Metals Processing Div., NY (g)
Dare Products, Inc., Mich (b,g)
Detroit Steel Corp., Portsmouth Div., Mich (g)
Division Lead Co., Ill (d)
Dow Chemical Co., Magnesium Div., Mich (e)
Driver, Wilbur B. Co., NJ (b,f)
Driver-Harris Co., NJ (f)
Dudek & Bock Spring Mfg. Co., Ill (a,b,g)
Eaton Mfg. Co., Reliance Div., Ohio (a,b,e,g)
Edgcomb Steel & Aluminum Corp., NJ (a,g)
Electric Auto-Lite Co., Ohio (a,b)
Electric Steel Foundry Co., Ore (g)
Electronic Parts Mfg. Co., NJ (b,f)
Elgin National Watch Co., Ill (f)
Empire Metal Co., NY (d)
Erskine Precision Wire Corp., Pa (b,f,g)
Essex Industrial Products Div., Essex Wire Corp., Ind (a,b)
Essex Wire Corp., Magnet Wire Div., Ind (a,b)
Frasse, Peter A. & Co., Inc., NY (a,g)
Fromson Orban Co., Inc., NY (a)
General Alloys Co., Mass (a,b,f,g)
General Cable Corp., NY (a,b)
General Chain & Mfg. Corp., Ohio (g)
General Findings & Supply Co., Industrial Div., Mass (a,b,c,f,g)
Greene, G.G. Corp., Pa (g)
Hawkridge Bros. Co., Mass (a,h)
Hayden Wire Works, Inc., Mass (a,b,c,d,f,g,j)
Haynes Stellite Co., Div. of Union Carbide Corp., Ind (f)
Hazledine, E.T. Co., Ind (g)
Hi-Grade Alloy Corp., Ill (d)
Hoskins Mfg. Co., Mich (f,h)
Hudson Wire Co., NY (a,b,j)
Indiana Steel & Wire Co., Inc., Ind (g)
Indium Corp. of America, NY (d)
International Nickel Co., Inc., NY (f)
Jarco Metal Products, NY (g)
Jelliff, C.O. Mfg. Corp., Conn (f)
Johnson Steel and Wire Co., Inc., Mass (g)
Jones & Laughlin Steel Corp., Pa (g)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Kanthal Corp., Conn (c,f)
Kassel Export Co., Inc., NJ (a,b,c,g)
Kelsey-Hayes Co., Metals Div., NY (f)
Keystone Steel & Wire Co., Ill (g)
Laclede Steel Co., Mo (g)
Langsenkamp, F.H. Co., Ind (b)
La Salle Steel Co., Mo (g)
Leach & Garner Co., Mass (b,f)
Lincoln Steel Corp., Neb (g)
Little Falls Alloys, Inc., NJ (a,b,h)—Ad p 440
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (a,b,e,g)
Manganese Steel Forge Co., Pa (g)
Matthiessen & Hegeler Zinc Co., Ill (j)
Melco Wire Products, Calif (a)
Metal Goods Corp., Mo (a,b,f)
Metallizing Co. of Los Angeles, Inc., Calif (a,b,c,d,f,g,j)
Mid-States Steel & Wire Co., Ind (g)
Mid-West Wire Products Co., Inc., Mich (g)
National Electric Div., H.K. Porter Co., Pa (a)
National Lead Co., NY (d,h)
National Lock Washer Co., NJ (g)
National-Standard Co., Mich (b,c,f,g,h,j)—Ad p 421
Nesor Alloy Products Co., NJ (a,b,c,d,f,g,j)
New England Electrical Works, Inc., NH (b)
Nichols Wire & Aluminum Co., Iowa (a)
Northwestern Steel & Wire Co., Ill (g)
Okonite Co., Sub. of Kennecott Copper Corp., NJ (b)
Olin Mathieson Chemical Corp., Metals Div., NY (a)
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa (g)—Ad p 446
Peerless Wire Goods Co., Inc., Ind (g)
Philadelphia Steel & Wire Corp., Pa (g)
Pittsburgh Steel Co., Pa (g)
Reactive Metals, Inc., Ohio (h)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass Inc., NY (b)
Reynolds Aluminum Supply Co., Ga (a)
Reynolds Metals Co., Va (a)
Riverside-Alloy Metal Div., H. K. Porter Co., Inc., NJ (b,f,g)
Roebling's John A. Sons Div., Colorado Fuel & Iron Corp., NJ (a,b,g)
Rolled Alloys, Inc., Mich (f)
Rolock, Inc., Conn (f)
Ryerson, Joseph T. & Son, Inc., Ill (a,g)
Sandvik Steel, Inc., NJ (g)
Scovill Mfg. Co., Mill Products Div., Conn (b)
Seneca Wire & Mfg. Co., Ohio (g)
Sherman & Reilly, Inc., Tenn (g)
Simonsen Metal Products Co., Ill (a)
South River Metal Products Co., Inc., NJ (a)
Southern Metal Products Co., La (g)
Standard Metals Corp., Mass (b,f)
Star Heel Plate Co., Inc., NJ (a,b,g)
Stulz-Sickles Co., NJ (g)
Superior Mfg. Co., Pa (g)
Surprenant Mfg. Co., Mass (b)
Sylvania Electric Products, Inc., Parts Div., Pa (b,c,f,g)
Techalloy Co., Inc., Pa (f,g,h)
Tennessee Coal and Iron Div., U. S. Steel Corp., Ala (b,g)
Titan Metal Mfg. Co., Pa (b)
Triangle Conduit & Cable Co., Inc., NJ (a,b)
U. S. Steel Corp., Pa (g)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium aid its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, Casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

United Wire & Supply Corp., RI (a, b)
Uniworld Research Corp. of America, Ohio (c)
Utility Mfg. Co., Mass (a,b,g)
Vanadium-Alloys Steel Co., Pa (g)
Wal-Mar Corp., Ill (a,b,c,e,g)
Washburn Wire Corp., Phillipsdale Div., RI (g)
Washington Mfg. Co., Inc., Iowa (g)
Wesco Spring Co., Ill (g)
White Metal Rolling & Stamping Corp., NY (a,e)
Whitehead Metal Products Co., Inc., NY (a,b,f,g)
Whyte, Oliver Co., Inc., NY (a,g)
Wickwire Brothers, Inc., NY (g)
Wilson Steel & Wire Co., Ill (g)
Worcester Wire Works Div., National-Standard Co., Mass (g,h)
Youngstown Sheet and Tube Co., Ohio (g)

Wire Cloth

(incl. parts)

Alabama Wire Co., Inc., Ala (a)
American Brass Co., Sub. of Anaconda Co., NY (b)
American Steel and Wire Div., U. S. Steel Corp., Ohio (g)
Arcos Corp., Pa (e,h)
Biersach & Niedermeyer Co., Wis (a, g)
Bishop, J. & Co. Platinum Works, Pa (g)
Buffalo Wire Works Co., Inc., NY (a,b,c,f,g)
Cambridge Wire Cloth Co., Md (a,b, c,d,f,g,h,j)
Chase Brass & Copper Co., Sub. of Kennecott Copper Corp., Conn (a,b,f)
Cleveland Wire Cloth & Mfg. Co., Ohio (a,b,c,f,g,h,j)
Cole-Roscoe Mfg. Co., Conn (b,f,g,h)
Colorado Fuel & Iron Corp., Pacific Coast Div., Calif (g)
Columbia-Geneva Steel Div., U.S. Steel Corp., Calif (g)
Electric Steel Foundry Co., Ore (g)
General Alloys Co., Mass (f)
General Cable Corp., NY (a,b)
Gilbert & Bennett Mfg. Co., Conn (a,g)
Green Bay Foundry & Machine Works, Wis (b,f)
Hewitt-Robins Inc., Conn (g)
Jelliff, C.O. Mfg. Corp., Conn (a,b,c, f,g)
Johnston & Funk Titanium Corp., Ohio (g,h)
Kassel Export Co., Inc., NJ (a,b,f)
Kenmore Machine Products, Inc., NY (f)
Manganese Steel Forge Co., Pa (a,b,c, f)
Metal Goods Corp., Mo (g)
Michigan Wire Cloth Co., Mich (a, b,f,g)
Mid-States Steel & Wire Co., Ind (g)
National-Standard Co., Mich (a,b,c,f,g,h,j)—Ad p 421
Newark Wire Cloth Co., NJ (a,b,c,f,g,h)—Ad p 454
Pequot Wire Cloth Co., Div. of Hudson Wire Co., Conn (a,b,f,g)
Phoenix Mfg. Co., Ill (g)
Reynolds Wire Div., National-Standard Co., Ill (a,b,c,d,f,g,h,j)
Rolock, Inc., Conn (a,b,f,g)
Rotometals, Calif (a,f)
Seymour Mfg. Co., Conn (b)
Sherman & Reilly, Inc., Tenn (g)
Sherwatt Equipment & Mfg. Co., Inc., NY (a,b,c,e,f,g,h,j)
Sinclair Co., Mass (b,g)
Star Heel Plate Co., Inc., NJ (g)
Star Wire Screen & Iron Works, Inc., Calif (a,b,c,f,g)
Taylor-Wharton Co., Div. of Harsco Corp., NJ (g)
Tennessee Coal and Iron Div., U. S. Steel Corp., Ala (g)
Tyler, W.S. Co., Ohio (a,b,c,f,g)
Unique Wire Weaving Co., Inc., NJ (a,b,c,e,f,g,h)
U. S. Steel Corp., Pa (g)
Uniworld Research Corp. of America, Ohio (c)
Wesbar Stamping Corp., Wis (c,g)
Whitehead Metal Products Co., Inc., NY (a,b,f)
Wickwire Bros., Inc., NY (a,b,g)
Wright, G.F. Steel & Wire Co., Mass (a,b,f,g)

Wire Forms and Parts

(except cloth)

Abalon Precision Mfg. Corp., NY (a, b,c,g)
Ace Wire Spring & Form Co., Inc., Pa (g)
Acme Stamping & Wire Forming Co., Pa (a,b,g)
All-Form Metal Products Co., Ohio (a,b,c,f,g)
Alox Mfg. Co., Mo (a,b,c,f,g)
Aluminum Co. of America, Pa (a)
American Mfg. Co., Tenn (a,g)
American Metal Products Co., Mich (a,g)
American Reed Co., Inc., Mass (c)
Anthes Div., Gleason Corp., Iowa (g)
Armco Steel Corp., Ohio (g)
Art Wire & Stamping Co., NJ (a,b,c,e,f,g,h,j)—Ad p 437
Associated Spring Corp., Wallace Barnes Steel Div., Conn (g)
Automotive Rubber Co., Inc., Mich (f, g)
Bethlehem Steel Co., Pa (g)
Blacher Bros., Inc., RI (b,g)
Blaco Mfg. Co., Ohio (g)
Buffalo Wire Works Co., NY (a,b,f,g)
Cambridge Wire Cloth Co., Md (a,b, f,g)
Cartwright, R. Tube Products Co., Mich (b)
Clendenin Bros. Inc., Md (a,b,g)
Cleveland Metal Products Co., Ohio (a,b,f,g)
Colorado Fuel and Iron Corp., Colo (g)
Colorado Fuel & Iron Corp., Pacific Coast Div., Calif (g)
Columbus Dental Mfg. Co., Ohio (g)
Comerford Mfg. Co., Inc., Conn (a,b, c,e,f,g)
Dare Products, Inc., Mich (g)
Dudek & Bock Spring Mfg Co., Ill (a,b,g)
Eastern Tool & Mfg. Co., NJ (a,b,g)
Electronic Parts Mfg. Co., Inc., NJ (b,f)
Elgin National Watch Co., Ill (f)
Empire Spring Co., Ohio (g)
Farwell Metal Fabricating, Minn (a, b,c,e,f,g)
Figley Die & Stamping Co., Ohio (g)
General Alloys Co., Mass (a,b,f)
General Cable Corp., NY (a)
General Chain & Mfg. Corp., Ohio (g)
General Findings & Supply Co., Industrial Div., Mass (a,b,c,f,g)
Grammes, L.F. & Sons, Inc., Pa (a, b,g)
Greene, G.G. Corp., Pa (g)
Hayden Wire Works, Inc., Mass (g)
Hodges, William & Co., Inc., Pa (g)
Hunter Spring Co., Div. of American Machine & Metals, Inc., Pa (a,b,f, g)
Industrial Precision Products, Ill (a, b,c,e,f,g,h,j)
Judd Industries, Inc., Ohio (a,g)
King Laboratories, Inc., NY (a,f,g)
Klise Mfg. Co., Mich (b,g)
Laclede Steel Co., Mo (g)
Larkin Specialty Mfg. Co., Calif (a, b,f,g)
Leach & Garner Co., Industrial Div., Mass (a,b,f)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (a,b,e,g)
Melco Wire Products, Calif (a)
Metal Textile Corp., NJ (a,b,c,f,g,h,k)
Mid-West Wire Products Co., Inc., Mich (g)
Morse, Fred W. Co., RI (a,b,g)
Newark Wire Cloth Co., NJ (a,b,f,g,h)
Northwestern Steel & Wire Co., Ill (g)
Ormond Mfg. Co., Inc., NJ (a,b,c,f, g,h)
Parker Metal Goods Co., Mass (a,b,c, g)
Penrod, Floyd & Sons Tool & Engineering Corp., Ind (g)
Pittsburgh Steel Co., Pa (g)
Reliable Spring & Wire Forms Co., Ohio (a,b,e,f)
Republic Steel Corp., Ohio (g)
Reynolds Wire Div., National-Standard Co., Ill (a,b,e,f)
Riverside-Alloy Metal Div., H.K. Porter Co., Inc., NJ (b,f,g)
Robertson Steel & Iron Co., Ohio (a, b,g)
Rockford Bolt & Steel Co., Ill (g)
Roebling's, John A. Sons Div., Colorado Fuel & Iron Corp., NJ (g)
Rolock Inc., Conn (a,b,f,g)
Scovill Mfg. Co., Mill Products Div., Conn (a,b,c,f,g)
Servwell Products Co., Ohio (f)
Simonsen Metal Products Co., Ill (a)
Star Heel Plate Co., Inc., NJ (g)
Steel Heddle Mfg. Co., Pa (a,b,c,e,f, g)
Superior Mfg. Co., Pa (a,c,g,j)
Sylvania Electric Products, Inc., Parts Div., Pa (a,b,c,d,f,g)
Titchener, E.H. & Co., NY (a)
Turner & Seymour Mfg. Co., Conn (a, b,g)
United Wire & Supply Corp., RI (a,b)
U.S. Steel Supply Div., U.S. Steel Corp., Ill (g)
Wal-Mar Corp., Ill (a,b,c,g)
Ward, H.H. Co., Pa (a,b,c,f,g,j)
Washington Mfg. Co., Iowa (g)
Waterbury Buckle Co., Conn (a,b,g)
Wesco Spring Co., Ill (g)
Whyte, Oliver Co., Inc., Mass (g)
Wilder Mfg. Co., Inc., Calif (a,b,g)
Wire and Iron Products, Inc., Mich (a,b,c,f,g)
Wood, John Co., Minn (g)
Worth Co., Wis (a,b,e,g)

Wood—Balsa

Balsa Equador Lumber Corp., NY
Bogert & Hopper, Inc., NY
Emery, George D. Co., NY
Foss Mfg. Co., Id
Gamble Brothers, Inc., Special Products Div., Ky
General Veneer Mfg. Co., Calif
International Balsa Corp., NJ
Monteath, J.H. Co., NY
Pollack, Robert Co., Calif
Sterling Models, Pa
Technical Ply-Woods Sales, Ill
Testor Chemical Co., Ill

Wood—Composition Board

Allied Chemical Corp., Plastics & Coal Chemicals Div., NY
Armstrong Cork Co., Pa
Artyle Industries, Inc., Ohio
Balsa Equador Lumber Corp., NY
Celotex Corp., Ill
Diamond Lumber Co., Ore
Gamble Brothers, Inc., Special Products Div., Ky
Georgia-Pacific Corp., Ore
Hardboard Div., Evans Products Co., Ore
Johns-Manville Corp., NY
Long-Bell Div., International Paper Co., Wash
Masonite Corp., Ill
National Starch & Chemical Corp., Structural Products Div., NY
Reynolds Aluminum Supply Co., Ga
Roddis Plywood Corp., Wis
Simpson Timber Co., Wash
Technical Ply-Woods Sales, Ill
U. S. Gypsum Co., Ill
Wal-Mar Corp., Ill
West Virginia Pulp & Paper Co., NY
Weyerhaeuser Timber Co., Silvatek Products Div., Wash

Wood—Impregnated and/or Compressed

American Polyglas Corp., NJ
Armstrong Cork Co., Pa
Diamond Lumber Co., Ore
Everlite Corp., Wash
Fibron Products, Inc., NY
Formica Corp., Sub. of American Cyanamid Co., Ohio
Gamble Brothers, Inc., Special Products Div., Ky
Georgia-Pacific Corp., Ore
Hardboard Div., Evans Products Co., Ore
Micarta Div., Westinghouse Electric Corp., SC
Parkwood Laminates, Inc., Mass
Permali, Inc., Pa
Ren Plastics Inc., Mich
Reynolds Aluminum Supply Co., Ga
Simpson Timber Co., Wash
Technical Ply-Woods Sales, Ill
West Virginia Pulp & Paper Co., NY
Wood Conversion Co., Minn

Wood—Lignum Vitae

Lignum-Vitae Products Corp., NJ

Wood—Plywood

American Plywood Div., Curtis Cos., Inc., Wis
Artyle Industries, Inc., Ohio
Balsa Equador Lumber Corp., NY
Darlington Veneer Co., SC
Delta Plywood Corp., Ark
Diamond Lumber Co., Ore
Gamble Brothers, Inc., Ky
Georgia-Pacific Corp., Ore
Long-Bell Div., International Paper Co., Wash
Nu-Ply Corp., Minn
Puget Sound Plywood, Inc., Wash
Reynolds Aluminum Supply Co., Ga
Roddis Plywood Corp., Wis
Simpson Timber Co., Wash
Technical Ply-Woods Sales, Ill
Timber Products Co., Ore
U. S. Plywood Corp., NY
West Virginia Pulp & Paper Co., NY

Wool Felts

(see Felts)

Wrought Iron

(see Iron)

Zinc and Its Alloys

Advance Stamping Co., Mich (dd)
Allied Research Products, Inc., Md (n)
Alpha Metals, Inc., NJ (v)
American Metal Climax, Inc., NY (o,w)

American Nickel Alloy Mfg. Corp., NY (q,w)
American Silver Co., NY (v,dd)
American Smelting & Refining Co., NY (n,v,w)
American Zinc Sales Co., Mo (n,o,q,w,z)
Anchor Metal Co., Inc., NY (w)
Apex Smelting Co., Ill (w)
Belmont Smelting & Refining Works, Inc., NY (n,o,v,w,z,aa,bb,cc,dd,ff)
Bunker Hill Co., Calif (n,o,z,cc,dd)
Cerro de Pasco Sales Corp., NY (w)
Chicago Smelting & Refining Corp., Ill (w)
Clark Perforating Co., Mich (cc)
Dixon Sintaloy, Inc., Conn (o)
Duane Specialties, Ltd., NJ (w)
Eagle-Picher Co., Ohio (g,aa)
Empire Metal Co., NY (n,o,q,v,w,z,bb,cc,dd,ff)
Federated Metals Div., American Smelting & Refining Co., NY (n,w)
Fox Products Co., Pa (n)
General Smelting Co., Pa (n,w,aa)
Hardy, Charles, Inc., NY (aa)
Harshaw Chemical Co., Ohio (n)
Hayden Wire Works, Inc., Mass (ff)
Hi-Grade Alloy Corp., Ill (n,o)
Hodgson Foundry Co., Ill (n)
Hull, R.O. & Co., Inc., Ohio (n)
Illinois Smelting & Refining Co., Ill (o,w,z,aa,bb,cc,dd)
Illinois Zinc Co., Div. of Hydrometals, Inc., Ill (w,z,bb,cc,dd)
International Minerals and Metals Corp., NY (w)
Jordan Co., Ill (w)
Kirk, Morris P. & Son, Calif (n)
Lavin, R. & Sons, Inc., Ill (n,w)
Matthiessen & Hegeler Zinc Co., Ill (n,o,q,v,w,z,aa,bb,cc,dd)
McGean Chemical Co., Ohio (n,o,aa)
Metallizing Engineering Co., Inc., NY (ff)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Metals Disintegrating Co., Inc., NJ (aa)
Modern Plating Corp., Ill (n)
National Galvanizing Co., Pa (w)
National Lead Co., NY (n,o,q,w,z,bb,cc,dd,ee)
Nesor Alloy Products Co., NJ (ff)
New England Smelting Works, Inc., Mass (o,w)
New Jersey Metals Co., NJ (n)
New Jersey Zinc Co., NY (n,w,z,aa,dd)—Ad pp 452-453
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Peerless Alloy Co., Colo (o,w)
Pittsburgh Smelting & Refining Co., Pa (w)
Republic Metals Co., Inc., NY (n,o,w)
Rotometals, Calif (n,o,w,aa,bb,cc,dd,ff)
St. Joseph Lead Co., NY (w)
Sall, George Metals Co., Inc., Pa (n,w)
Security Sash & Screen Co., Mich (cc)
Stevens, Frederic B., Inc., Mich (n)
Udylite Corp., Mich (n)
U. S. Reduction Co., Ind (w)
U. S. Smelting, Refining & Mining Co. NY (w)
Wall Colmonoy Corp., Mich (aa)
White Metal Rolling & Stamping Corp., NY (o,bb,ff)
Whitehead Metal Products Co., Inc., NY (cc,dd,ee)

Zirconium and Its Alloys

Allegheny Ludlum Steel Corp., Pa (o,q,v,w,z,bb,cc,dd,ee,ff)
American Silver Co., NY (v,dd,ee,ff)
Arcos Corp., Pa (ff)
Babcock & Wilcox Co., Tubular Products Div., Pa (ee)
Belmont Smelting & Refining Works, Inc., NY (aa)
Bishop, J. & Co. Platinum Works, Pa (ee)
Bridgeport Brass Co., Conn (ee)
Brooks & Perkins, Inc., Mich
Carborundum Co., NY (o,q,r,v,w,z,bb,cc,dd,ee,ff)
Carborundum Metals Co., NY (o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Carpenter Steel Co., Alloy Tube Div., NY (ee)
Chase Brass & Copper Co., Sub. of Kennecott Copper Corp., Conn (ee)
Columbia National Corp., Pa (w)
Crucible Steel Co. of America, Pa (ee)
Damascus Tube Co., Pa (ee)
Electric Steel Foundry Co., Ore (o,q,w,bb,ee)
Foote Mineral Co., Pa (o,v,aa,bb,cc,ff)
General Electric Co., Metallurgical Products Dept., Mich (q,w,aa,bb,cc,dd)
Hamilton Watch Co., Precision Metals Div., Pa (v,bb,cc,ff)
Hardy, Charles, Inc., NY (aa)
Harvey Aluminum, Calif (o,q,v,w,z,bb,cc,dd,ee,ff)
Hayden Wire Works, Inc. Mass (aa)
Johnston & Funk Titanium Corp., Ohio (bb,ff)
King Laboratories, Inc., NY (aa)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (a,dd,ee,ff)
Metal Forming Corp. Div., Vanadium-Alloys Steel Co., Pa (ee)
Metal Hydrides, Inc., Mass (aa)
Metallizing Co. of Los Angeles, Inc., Calif (cc,ff)
Michigan Seamless Tube Co., Mich (ee)
National Lead Co., NY (o,q,w,z,bb,cc,dd)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (w)
Nuclear Metals, Inc., Mass (w,bb,dd,ee,ff)
Oregon Metallurgical Corp., Ore (w,ee)
Reactive Metals, Inc., Ohio (o,q,v,w,z,bb,cc,dd,ee,ff)
Republic Steel Corp., Steel & Tubes Div., Ohio (ee)
Rodney Metals, Inc., Mass (v)
Superior Steel Corp., Pa (dd)
Superior Tube Co., Pa (ee)—Ad pp 414-415
Texas Instruments, Inc., Metals & Controls Div., Mass (v,cc,dd,ee,ff)
Trent Tube Co., Sub. of Crucible Steel Co. of America, Pa (ee)
Tube Reducing Corp., NJ (ee)
Wah Chang Corp., NY (w)—Ad p 164
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,w,z,bb,cc,dd,ee)
Zirconium Metals Corp., Sub. of National Lead Co., NY —Ad p 430

Addresses of Suppliers

a

A & A Die Casting Co., 12901 S Western Ave., Gardena, Calif.

ACF Industries, Inc., 30 Church St., New York 8, N.Y.

American Car & Foundry Div., 750 3d Ave., New York 17, N.Y.

aaRBee Plastic Co., 4505 W Jefferson Blvd., Los Angeles 16, Calif.

Abalon Precision Mfg. Corp., 540 Casanova St., New York 59, N.Y.

Abbott Ball Co., 1074 New Britain Ave., Hartford 10, Conn.

Abbott Products, Inc., 150-50 12th Ave., Whitestone 57, N.Y.

Abco Aluminum & Brass Works, 5235 Griggs Rd., Houston 21, Tex.

Abegg & Reinhold Co., 2533 E 26th St., Los Angeles 58, Calif.

Able Tool & Engineering Co., 865 N Sangamon St., Chicago 22, Ill.

Accurate Anodizing Corp., 4100 W Lake St., Chicago 24, Ill.

Accurate Die Casting Co., 3089 E 80th St., Cleveland 4, Ohio

Accurate Metal Weather Strip Co., Inc., 725 S Fulton Ave., Mt. Vernon, N.Y.

Accurate Molding Corp., 35-20 48th Ave., Long Island City 1, N.Y.

Ace Metal Spinning, 4922 S Western Ave., Chicago 9, Ill.

Ace Plastic Co., 91-30 Van Wyck Expy., Jamaica 35, N.Y.

Ace Wire Spring & Form Co., Inc., Tunnel Way, McKees Rocks, Pa.

Acheson Colloids Co., 1635 Washington, Pt. Huron, Mich.

Ackermann Mfg. Co., 1134-40 Market St., Wheeling, W. Va.

Acme Aluminum Foundry Co., 6831 S Bell Ave., Chicago, Ill.

Acme Foundry & Machine Co., Coffeyville, Kan.
Acme Foundry & Machine Co., 400 E Erisco, Blackwell, Okla.
Acme Galvanizing Co., 1733 17th St., Oakland 7, Calif.
Acme Mfg. & Gasket Co., 738-40 N 41st St., Philadelphia 4, Pa.
Acme Metal Spinning, Inc., 98 43rd Ave., NE, Minneapolis 21, Minn.
Acme Plating Co., 1563 E 21st St., Cleveland 14, Ohio
Acme Precision Products, Inc., 215 N Findlay St., Dayton 3, Ohio
Acme Resin Corp., 1401 Circle Ave., Forest Park, Ill.
Acme Specialties, Inc., 4326 N American St., Philadelphia 40, Pa.
Acme Stamping & Wire Forming Co., 201-209 Corliss St., Pittsburgh 20, Pa.
Acme Steel Co., Acme Steel Products Div., 135th St. & Perry Ave., Chicago 27, Ill.
Acme Steel & Malleable Iron Works, Buffalo 7, N.Y.
Acme Tube, Inc., 212 Coit St., Irvington 11, N.J.
Acme-Newport Steel Co., 9th & Lowell Sts., Newport, Ky.
Acorn Sheet Metal Mfg. Co., Inc., 4605 W 21st St., Chicago 50, Ill.
Acro Metal Stamping Co., 332 E Reservoir, Milwaukee 12, Wis.
Acushnet Process Co. (Ad p 448)
Belleville Ave., New Bedford, Mass.
Adams Engineering Co., Inc., 19300 Biscayne Blvd., Miami, Fla.
Adams, I. G., Metalware Co., 2947 Delmar Pl., St. Louis, Mo.
Adams Plastic Products, Finlay & Providence Sts., Cincinnati, Ohio
Adhesive Products Corp., 1660 Boone Ave., New York 60, N.Y.
Adirondack Steel Casting Co., Watervliet, N.Y.
Admiral Corp., Molded Prods. Div., P.O. Box 338, West Chicago, Ill.
Advance Aluminum Castings Corp., 2742 W 36th Place, Chicago 32, Ill.
Advance Foundry Co., 107 Seminary Ave., Dayton, Ohio
Advance Galvanizing Co., 5332 Alcoa Ave., Los Angeles 58, Calif.
Advance Pressure Castings, Inc., 20 Wythe Ave., Brooklyn 11, N.Y.
Advance Screw Products Co., Inc., 3767 S Kinnickinnic Ave., Milwaukee 7, Wis.
Advance Stamping Co., 12025 Dixie Ave., Detroit 39, Mich.
Advance Tool & Die Casting Co., 3760 N Holton St., Milwaukee 12, Wis.
Aelco Foundries, Inc., 1980 S 4th St., Milwaukee 4, Wis.
Aerojet-General Corp., Structural Materials Div., 6352 N. Irwindale St., Azusa, Calif.
Aerolite Electronics Corp., 2207 Summit Ave., Union City, N.J.
Aerolite Extrusion Co., 4605 Lake Park, Youngstown, Ohio
Aetna Felt Co., Inc., 204 Centre St., New York 13, N.Y.
Aetna Steel Co., P.O. Box 2090, Jacksonville 3, Fla.
Affiliated Screw Products Co., 3800 Wesley Terrace, Schiller Park, Ill.
African Metals Corp., 25 Broad, New York 4, N.Y.
Air Reduction Co., Inc., 150 E 42nd St., New York 17, N.Y.
Air Reduction Chemical Co. Div., 150 E 42nd St., New York, N.Y.
Air Reduction Sales Co., 150 E 42nd St., New York 17, N.Y.
Colton Chemical Co., 1747 Chester Ave., Cleveland 14 Ohio
Akron Porcelain Co., 2723 Cory Ave., Akron 14, Ohio
Akron Standard Mold Co., Lecromelt Casting Div., Houston St., Barberton, Ohio
Alabama Metallurgical Corp., P.O. Box 38, Selma, Ala.
Alabama Wire Co., Inc., Terrace St., Florence, Ala.
Aladdin Transparent Packaging Corp., 608 Main St., Westbury, N.Y.
Alan Wood Steel Co., Wood Rd., Conshohocken, Pa.
Albany Car Wheel Co., Inc., 185 Broadway, Menends, N.Y.
Albany Felt Co., Broadway, Albany 1, N.Y.
Albany Novelty Mfg. Co., 107 W Canton St., Boston 18, Mass.
Albany Products Co., Inc., 351 Connecticut Ave., South Norwalk, Conn
Albert Lea Foundry Co., 910 Marshall Ave., Albert Lea, Minn.
Albert Pipe Supply Co., Inc., 101 Varick Ave., Brooklyn 37, N.Y.
Albion Malleable Iron Co., 601 N Albion St., Albion, Mich.
Albraco Metals Corp., 649 Van Sinderen Ave., Brooklyn 7, N.Y.
Albright Son & Co., 123 N Front St., Allentown, Pa.
Alcasco Foundry, 14823 Loomis Ave., Harvey, Ill.
Alchemize Corp., 625 S Kolmar Ave., Chicago 24, Ill.
Alco Products, Inc., 30 Church St., New York, N.Y.
Alcylite Plastics & Chemical Corp., 23874 N Pine St., Newhall, Calif.
Aldan Rubber Co., Tioga & Salmon Sts., Philadelphia 34, Pa.
Alexander Bros. Belting Co., Franklin & Suffolk, Worcester, Mass.
Alexander, E. P. & Son, Clifton Heights, Pa.
Allegheny Foundry Co., 915 Behan St., Pittsburgh 33, Pa.
Allegheny Ludlum Steel Corp. (Ad p 37)
Oliver Bldg., Pittsburgh 22, Pa.
Allegheny Plastics, Inc., Rt. 51 & Thorn Run Rd., Coraopolis, Pa.
Allen Mfg. Co., Drawer 570, Hartford 1, Conn
Allen-Stevens Corp., 33-53 62nd St., Woodside 77, N.Y.
All-Form Metal Products Co., 13000 Athens Ave., Cleveland 7, Ohio
AllianceWare, Inc., AllianceWall Div., Box 809, Alliance, Ohio
Allied Chemical Corp., 61 Broadway, New York 6, N.Y.
Plastics & Coal Chemicals Div., 40 Rector St., New York 6, N.Y.
Solvay Process Div. (Ad p 349)
61 Broadway, New York 6, N.Y.
Allied Machine Products Co., 6174 Concord Ave., Detroit 11, Mich.
Allied Metal Products Co., 81 Prescott St., Worcester 6, Mass.
Allied Products Corp., 12677 Burt Rd., Detroit 23, Mich.
Allied Research Products, Inc. (Ad p 358)
4004 W Monument St., Baltimore 5, Md.
Allied Resinous Products, Inc., Clark & Whitney Sts., Conneaut, Ohio
Allied Steel Castings Co., 1225 W 120th St., Chicago 43, Ill.
Allied Tube Corp., Bristol & Bath Sts., Philadelphia 37, Pa.
Allis-Chalmers Mfg. Co., 501 N 3rd St., La Crosse, Wis.
Allmetal Screw Products Co., Inc., 821 Stewart Ave., Garden City, N.Y.
All-Metals Precision Casting Corp., 22 School St., Yonkers, N.Y.
Alloy Cast Steel Co., Rose Ave., Marion, Ohio
Alloy Engineering & Casting Co., 1700 W Washington St., Champaign, Ill.
Alloy Metal Powders, Inc., 238 Eagle St., Brooklyn, N.Y.
Alloy Metal Products Inc., 2333 Rockingham Rd., Davenport, Iowa
Alloy Metal Wire Co., Inc., Moore Station, Prospect Park, Pa.
Alloy Precision Castings Co., 3857 W 150th St., Cleveland 11, Ohio
Alloy Products Corp., 1045 Perkins Ave., Waukesha, Wis.
Alloy Rods Co., Lincoln Hwy. W, York, Pa.
Alloy Steel Casting Co., County Line Rd., Southampton, Pa.
Alloy Steel & Metals Co., 1848 E 55th St., Los Angeles 58, Calif.
Alloy Surfaces Co., Inc., 100 S Justison St., Wilmington 1, Del.
Alloys & Chemicals Mfg. Co., Inc., 4365 Bradley Rd., SW, Cleveland 9, Ohio
All-State Welding Alloys Co., Inc., 249 Ferris Ave., White Plains, N.Y.
Almco Steel Products Corp., Wabash Ave., Bluffton, Ind.
Almont Mfg. Co., 335 E 3rd St., Imlay City, Mich.
Alofs Mfg. Co., 345 32nd St. SW, Grand Rapids 8, Mich.
Alox Mfg. Co., 6160 Maple Ave., St. Louis 14, Mo.
Alpha Metals, Inc., 56 Water St., Jersey City, N.J.
Alphaloy Corp. Div., 2250 S Lumber St., Chicago, Ill.
Alpha Plastics, Inc., 78 Okner Pkwy., Livingston, N.J.
Alpha Wire Corp., 200 Varick St., New York 14, N.Y
Alpha-Molykote Corp., 65 Harvard Ave., Stamford, Conn.
Alsynite Co. of America, 4654 De Soto St., San Diego 9, Calif.
Alten Foundry & Machine Works, Inc., 2000 W Wheeling St., Lancaster, Ohio
Aluminium Ltd. Sales, Inc., 630 5th Ave., New York 20, N.Y.
Aluminum Alloys Corp., 6650 W Walton Ave., Detroit 10, Mich.
Aluminum Billets, Inc., 3786 Oakwood Ave., Youngstown, Ohio
Aluminum Casting & Engineering Co., 2039 S Lenox St., Milwaukee 7, Wis.
Aluminum Co. of America (Ad pp 423-424)
1501 Alcoa Bldg., Pittsburgh 19, Pa
Industrial Foil Div., 1655-E Alcoa Bldg., Pittsburgh 19, Pa.
Aluminum Extrusions, Inc., 815 Shepherd St., Charlotte, Mich.
Aluminum Finishing Corp., 1012 E 21st St., Indianapolis 2, Ind.
Aluminum Foils Co., P.O. Box 540, Jackson, Tenn.
Aluminum Goods Mfg., Manitowoc, Wis.
Aluminum Industries, Inc., 3670 Werk Rd., Cincinnati, Ohio
Aluminum & Magnesium, Inc., 1 Huron St., Sandusky, Ohio
Aluminum Permanent Mold Co., 1054 Front Ave., NW, Grand Rapids 4, Mich.
Aluminum Specialty Co., 16th & Wollmer Sts., Manitowoc, Wis.
Amalgamated Steel Corp., 7835 Broadway Ave., Cleveland 5, Ohio
Ambassador Plastics & Mfg. Corp., 308 W Erie, Chicago 10, Ill.
Ambrit Industries, Inc., 1288 Los Angeles St., Glendale 4, Calif.
Amchem Products, Inc., Ambler, Pa.
Amco Plastic Pipe Co., 2002 Davis St., San Leandro, Calif.
Amerace Corp., 200 W 42nd St., New York, N.Y.
American Hard Rubber Co. Div., Ace Rd., Butler, N.J.
Supplex Co. Div., 225 North Ave., Garwood, N.J.
Amercoat Corp., 4809 Firestone Blvd., South Gate, Calif.
American Agile Corp., 5461 Dunham Rd., Maple Heights, Ohio
American Aluminum Co., 230 Sheffield St., Mountainside, N.J.
American Aluminum Casting Co., 300 Coit St., Irvington 11, N.J.
American Asbestos Textile Corp., Stanbridge St., Norristown, Pa.
American Brake Shoe Co., 530 5th Ave., New York 36, N.Y.
American Brakeblok Div., 900 W Maple Rd., Troy, Mich.
American Manganese Steel Div., 389 E 14th St., Chicago Heights, Ill.
Amforge Div., 1220 W 119th St., Chicago 43, Ill.
Brake Shoe & Castings Div., 230 Park Ave., New York, N.Y.
Electro-Alloys Div., Taylor St. & Abbe Rd., Elyria, Ohio
Engineered Castings Div., Mountain Read Rd. & NYCRR, Rochester 11, N.Y.
Light Metals Dept., Railroad Ave., Mahwah, N.J.
National Bearing Div., 717 Grant Bldg., Pittsburgh 19, Pa.
American Can Co., Plastics Div., 100 Park Ave., New York, N.Y.
American Cast Iron Pipe Co. (Ad p 410)
2930 16th St. N, Birmingham, Ala.
American Chain & Cable Co., Inc., Reading, Pa.
Acco Steel Casting Div., Tulpehocken St., Reading, Pa.
American Chain Div., 454 E. Princess St., York, Pa.
Page Steel & Wire Div. (Ad p 446)
Box 692, Monessen, Pa.
American Crucible Products Co., 1319 Oberlin Ave., Lorain, Ohio
American Cyanamid Co., 30 Rockefeller Plaza, New York 20, N.Y.
Formica Corp. Sub., 4614 Spring Grove Ave., Cincinnati 32, Ohio
Plastics & Resins Div. (Ad pp 251-254)
30 Rockefeller Plaza, New York 20, N.Y.
American Electric Cable Co., 181 Appleton St., Holyoke, Mass.
American Electrical Products Co., P.O. Box 200, 653 Lida St., Mansfield, Ohio
American Emblem Co., Inc., P.O. Box 116, Utica 1, N.Y.
American Enka Corp., William Brand-Rex Div., 31 Sudbury Rd., Concord, Mass.
American Fabricated Products Co., 1420 E 20th St., Indianapolis 7, Ind.
American Felt Co. (Ad p 312)
Glenville, Conn.
American Forge & Mfg. Co., P.O. Box 20, McKees Rocks, Pa.
American Foundries Co., 330 2nd St., Milan, Mich.
American Foundry Co., Inc., 1100 S Fibles Ave., Indianapolis 21, Ind.
American Insulator Corp., New Freedom, Pa.
American Latex Products Corp., 3341 W El Segundo Blvd., Hawthorne, Calif.
American Laundry Machinery Co., Rochester, N.Y.
American Lava Corp., Cherokee Blvd. & Mfrs. Rd., Chattanooga 5, Tenn.
American Light Alloys, Inc., 1265 McBride Ave., Little Falls, N.J.
American Machine & Foundry Co., Cleveland Welding Div., W 117th St., Cleveland 11, Ohio
American Machine & Metals Inc., Hunter Spring Co. Div., 1 Spring Ave., Lansdale, Pa.
American Malleable Castings Co., Marion, Ohio
American Manganese Bronze Co., Rhawn & Torresdale Aves., Philadelphia 36, Pa.

Addresses of Suppliers

American Mannex Corp., Easton Metal Powder Co. Div., 900 Line St., Easton, Pa.
American Mfg. Co., 124 Chestnut, Chattanooga 2, Tenn.
American Metal Climax, Inc., 1270 Ave. of the Americas, New York 20, N.Y.
Amco Div. (Ad pp 165-168)
61 Broadway, New York 6, N.Y.
Climax Molybdenum Div., 500 Fifth Ave., New York 36, N.Y.
American Metal Products Co., 5959 Linsdale Ave., Detroit 4, Mich.
American Metal Products, Inc., 4500 W Mitchell Ave., Cincinnati 32, Ohio
American Metallurgical Products Co., P.O. Box 11068, Pittsburgh 37, Pa.
American Metaseal Corp., 607 65th St., West New York, N.J.
American Molding Co., 2002 Davis St., San Leandro, Calif.
American Molding Powder & Chemical Co., 703 Bedford Ave., Brooklyn 8, N.Y.
American Nickel Alloy Mfg. Corp., 30 Vesey St., New York 7, N.Y.
American Nickeloid Co., 2nd & West Sts., Peru, Ill.
American Pipe & Construction Co., Northwest Div., 518 N E Columbia Blvd., Portland 11, Ore.
American Plastics Corp., 342 Madison Ave., New York 17, N.Y.
American Platinum Works, Newark 5, N.J.
American Polyglas Corp., Broad & 14th Sts., Carlstadt, N.J.
American Potash & Chemical Corp., 3000 W 6th St., Los Angeles 54, Calif.
Lindsay Chemical Div., 258 Ann St., West Chicago, Ill.
American Powdered Metals, Inc., 7-9 Philip Pl., North Haven, Conn.
American Products Corp., 525 S Dearborn St., Chicago 5, Ill.
American Products Mfg. Co., Inc., 8127-33 Oleander St., New Orleans 18, La.
American Reed Co., Inc., 2 S Broadway, Lawrence, Mass.
American Rubber Products Corp., 315 Brighton St., LaPorte, Ind.
American Sanitary Mfg. Co., Box 111, Abingdon, Ill.
American Screw Co., W Main St., Willimantic, Conn.
American Screw Products Co., 5943 Martin Ave., P. O. Box 96, Detroit 10, Mich.
American Sealants Co., 103 Woodbine St., Hartford 6, Conn.
American Sheet Metal Works, Inc., 16 Jefferson St., Waterbury 20, Conn.
American Silver Co., Inc., 36-07 Prince St., Flushing 54, N.Y.
American Sinteel Corp., 1019 Saw Mill River Rd., Yonkers, N.Y.
American Smelting & Refining Co., 120 Broadway, New York 5, N.Y.
Continuous Cast Products Div. (Ad pp 432-433)
1160 State St., Barber, N.J.
Federated Metals Div. (Ad p 173)
120 Broadway, New York 5, N.Y.
Lake Asbestos of Quebec, Ltd., Sub. (Ad pp 316-317)
120 Broadway, New York 5, N.Y.
American Solder & Flux Co., 19th & Willard Sts., Philadelphia 40, Pa.
American Stamping Co., 26650 Lakeland Blvd., Cleveland 32, Ohio
American Standard Co., Youngstown Kitchens Div., Ellsworth Ave., Salem, Ohio
American Steel Foundries, Prudential Plaza, Chicago 1, Ill.
American Steel & Pump Corp., Oklahoma Steel Castings Div., 1200 N Peoria Ave., Tulsa, Okla.
American Synthetic Rubber Corp., 500 5th Ave., New York 36, N.Y.
American Tape Co., 4058 Beaufait Ave., Detroit 7, Mich.
American Tinning & Galvanizing Co., 552 W 12th St., Erie, Pa.
American Valve & Enameling Corp., 2855 S Holt Rd., Indianapolis 41, Ind.
American Viscose Corp. (Ad p 313)
1617 Pennsylvania Blvd., Philadelphia 3, Pa.
American Welding and Mfg. Co., 100 Dietz Rd., Warren, Ohio
American Zinc Sales Co., 1522 Paul Brown Bldg., St. Louis 1, Mo.
American-Marietta Co., 101 E Ontario St., Chicago 11, Ill.
Adhesive, Resin & Chemical Div., 3400 13th Ave., SW, Seattle 4, Wash.
Booty Resineers Div., 42 S 3rd St., Newark, Ohio
Presstite Div., 3738 Chouteau Ave., St. Louis, Mo.
Sierra Metals Corp. Sub., 12th St. & W Strong Ave., Wheeling, Ill.
Ames, W. & Co., 417 Communipaw Ave., Jersey City 4, N.J.
Amos-Thompson Corp., Amos Molded Plastics Div., Edinburg, Ind.
Ampco Metal, Inc., 1753 S 38th St., Milwaukee 46, Wis.
Anaconda Co., 25 Broadway, New York 4, N.Y.
American Brass Co., 25 Broadway, New York 4, N.Y.
Anaconda Metal Hose Div., 698 S Main St., Waterbury 20, Conn.
Anaconda Aluminum Co., P.O. Box 1654, Louisville 1, Ky.
Anchor Hocking Glass Corp., Lancaster, Ohio
Anchor Metal Co., Inc., 966 Meeker Ave., Brooklyn 22, N.Y.
Anchor Metal Spinning Co., 46 Fluhart Ave., Dayton 8, Ohio
Anchor Plastics Co., 36-36 36th St., Long Island City 6, N.Y.
Anderson, O.L. Co., Inc., 1347 E Fort St., Detroit 7, Mich.
Anderson Assoc., Inc., 1702 Wayne St., Toledo 1, Ohio
Anderson-Bolling Mfg. Co., Grand Haven, Mich.
Anesite Co., 3575 Touhy Ave., Chicago 45, Ill.
Anti-Corrosive Metal Products Co., Inc., Castleton-on-Hudson, N.Y.
Apex Foundry, Inc., 633 Lycaste Ave., Detroit 14, Mich.
Apex Smelting Co., 2537 W Taylor St., Chicago 12, Ill.
Apex Steel Corp., Ltd., 6920 E Slauson, Los Angeles 22, Calif.
Apollo Metal Works, 6852 S Oak Park Ave., Chicago, Ill.
Appleton Electric Co., 1701 W Wellington Ave., Chicago 13, Ill.
Applied Instruments, Inc., 25 Will Pl., Brooklyn 7, N.Y.
Approved Mfg. Co., Inc., 307990 W 8th Mile Rd., Farmington, Mich.
Arabol Mfg. Co., 110 E 42nd St., New York 17, N.Y.
Arbonite Corp., 900 N Main St., Doylestown, Pa.
Archer-Daniels-Midland Co., 700 Investors Bldg., Minneapolis, Minn.
Arcos Corp., 1500 S 60th St., Philadelphia 43, Pa.
Ardmore Products, Inc., 194 Aldene Rd., Roselle, N.J.
Argosy Products, Inc., 7504 Carnegie Ave., Cleveland 3, Ohio
Aries Laboratories, Inc., 225 Greenwich Ave., Stamford, Conn.
Arkansas Foundry Co., 1423 E 6th St., Box 231, Little Rock, Ark.
Armco Steel Corp., 703 Curtis St., Middletown, Ohio
Fabricating Div., Middletown, Ohio
Sheffield Div., Sheffield Sta., Kansas City 25, Mo.
Armet Alloys, Inc., 4338 Bradley Rd., Cleveland 9, Ohio
Armitage, J. L. & Co., 245 Thomas St., Newark, N.J.
Armor Galvanizing Works, Inc., 580 Market St., San Francisco 4, Calif.
Armor Metal Products Co., 3408 Beekman, Cincinnati 23, Ohio
Armour & Co., Adhesive Div., 1355 W 31st St., Chicago, Ill.
Armstrong Cork Co., West Liberty St., Lancaster, Pa.
Armstrong Products Co., P.O. Box 1-MM, Warsaw, Ind.
Arneson Foundry Co., 3303 66th St., Kenosha, Wis.
Arnold Engineering Co., P.O. Box G, Marengo, Ill.
Arrow Metal Products Corp., 3rd Ave., Haskell, N.J.
Arrow Sintered Products Co., 1900 S Kostner Ave., Chicago 23, Ill.
Arrowhead Products, 2300 Curry St., Long Beach 5, Calif.
Art Wire & Stamping Co. (Ad p 437)
227 High St., Newark 2, N.J.
Artex Felt Co., 62 W 39th St., New York 18, N.Y.
Artmor Plastics Corp., 1003 Oldtown Rd., Cumberland, Md.
Artus Corp., 201 S Dean St., Englewood, N.J.
Artyle Industries, Inc., Box 28, Eaton, Ohio
Arvin Industries, Inc., 13th St., Columbus, Ind.
Arwood Corp., 321 W 44th St., New York 36, N.Y.
Arzt, T. L. Foundry Co., 4020 W Schubert Ave., Chicago 39, Ill.
Asbestos Corp. of America, 31 North Ave., Garwood, N. J.
Asbestos Textile Co., Inc., 165 W Wacker Drive, Chicago 1, Ill.
Asco Sintering Corp., 7799 Telegraph Rd., Los Angeles 22, Calif.
Ashby Mfg. Co., 1601 Woodson Rd., St. Louis 11, Mo.
Asheville-Schoonmaker Mica Co., 900 Jefferson Ave., Newport News, Va.
Ashland Oil & Refining Co., Valvoline Oil Co. Div., 3rd Ave., Freedom, Pa.
Ashtabula Mfg. Co., W 30th St., Ashtabula, Ohio
Associated Engineering & Mfg. Corp., 210 Stonehouse Rd., Glen Ridge, N. J.
Associated Spring Corp., Wallace Barnes Steel Div., 18 Main St., Bristol, Conn.
Atlantic Bag Co., 435 S 5th St., Brooklyn 11, N.Y.
Atlantic Brass Works, Inc., 2600 W Addison St., Chicago 18, Ill.
Atlantic Casting Engineering Corp. (Ad p 438)
810 Bloomfield Ave., Clifton, N.J.
Atlantic Foundry Co., 182 Beaver St., Akron 4, Ohio
Atlantic India Rubber Works, Inc., 569 W Polk St., Chicago 7, Ill.
Atlantic Powdered Metals, Inc., 38 Park Row, New York 38, N.Y.
Atlantic Steel Co., P.O. Box 1714, Atlanta 1, Ga.
Atlantic Steel Castings Co., 6th & Lloyd Sts., Chester, Pa.
Atlas Brass Foundry, 1901 Santa Fe Ave., Los Angeles 21, Calif.
Atlas Drop Forge Co., 209 W Mt. Hope Ave., Lansing, Mich.
Atlas Foundry Co., 3600 W 69th St., Cleveland 2, Ohio
Atlas Foundry & Machine Co., 3012 S Wilkeson St., Tacoma, Wash.
Atlas Foundry & Mfg. Co., 3701 Collins Ave., Richmond, Calif.
Atlas Galvanizing Co., 2639 Leonis Blvd., Los Angeles 11, Calif.
Atlas Metal Parts Co., 3232 N 31st St., Milwaukee 16, Wis.
Atlas Mineral Products Co., 161 Weber St., Mertztown, Pa.
Atlas Powder Co., Chemicals Div. (Ad p 262)
Wilmington 99, Del.
Atlas Steel Construction Co., 20 Vesey St., New York 7, N.Y.
Auburn Foundry, Inc., W 11th St., Auburn, Ind.
Auburn Mfg. Co. (Ad p 450)
20 Stack St., Middletown, Conn.
Auburn Plastic Engineering, 4916 S Loomis St., Chicago 9, Ill.
Auburn Plastics, Inc., 48 Canoga St., Auburn, N.Y.
Auburn Rubber Co., Inc., W 11th St., Auburn, Ind.
Auburn Spark Plug Co., Inc., Special Products Div., 89 York St., Auburn, N.Y.
Auel Industries, Herminie, Pa.
Auld, D. L. Co., 5th Ave. & 5th St., Columbus, Ohio
Aurora Metal Co., 614 W Park Ave., Aurora, Ill.
Aurora Refining Co., P.O. Box 88, Aurora, Ill.
Autel Electronics Co., Precision Machine & Welding Div., 1122 E St. George Ave., Linden, N.J.
Auto Specialties Mfg. Co., 643 Graves St., St. Joseph, Mich.
Automatic Nut Co., Lebanon, Pa.
Automotive Rubber Co., Inc., 12594 Beech Rd., Detroit, Mich.
Avco Mfg. Corp., 420 Lexington Ave., New York, N.Y.
New Idea Div., 420 Lexington Ave., New York, N.Y.
Avery Label Co., Decorative Products Div., 2123 E 9th St., Cleveland 15, Ohio
Aviation Developments, Inc., 210 S Victory Blvd., Burbank, Calif.
Avins Industrial Products Corp., 50 Broadway, New York 4, N.Y.
AviSun Corp. (Ad pp 244-245)
1608 Walnut St., Philadelphia 3, Pa.
Avondale Co., 260 Happ Rd., Northfield, Ill.
Avril, G. A. Co., Este Ave. & B&O R.R., Cincinnati, Ohio

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B. B. Chemical Co., Bostik Dept. (Ad p 496)
784 Memorial Dr., Cambridge 39, Mass.
B & T Metals Co., 425 W Town St., Columbus 16, Ohio
Babbitt Chemical Co., Inc., 38 Prospect, New Bedford, Mass.
Babcock & Wilcox Co., Tubular Products Div., Beaver Falls, Pa.
Babson Dow Mfg. Co., 64 Fulda St., Roxbury, Boston 19, Mass.
Backus Novelty Co., 411 Water St., Smethport, Pa.
Bacon Felt Co., 427 W Water St., Taunton, Mass.
Badger Aluminum Extrusions, 950 Georgia Ave., Brooklyn 7, N.Y.
Badger Die Casting Corp., 201 W Oklahoma Ave., Milwaukee 7, Wis.

In contacting suppliers, please mention the Materials Selector Issue

Badger Malleable & Mfg., Co., 223 N Chicago Ave., South Milwaukee, Wis.
Baer, N.S. Co., 1-11 Montgomery St., Hillside 5, N.J.
Baer Bros. Bronze Powder Co., Inc., Nickerson Rd., Ashland, Mass.
Baker & Co., Inc., 113 Astor St., Newark 2, N.J.
Balas Collet Mfg. Co., 1557 E 27th St., Cleveland 14, Ohio
Baldwin Mfg. Co., 140 Homer St., Waterbury 20, Conn.
Baldwin-Ehret-Hill, Inc., 500 Breunig Ave., Trenton 3, N.J.
Baldwin-Lima-Hamilton Corp., Philadelphia, Pa.
Standard Steel Works Div., Burnham, Pa.
Balsa Ecuador Lumber Corp., 500 5th Ave., New York, N.Y.
Bamberger, Claude P. Inc., 1 Mt. Vernon St., Ridgefield Park, N.J.
Bangor Plastics Inc., Washington St., Bangor, Mich.
Banner Iron Works, 1920 S Kingshighway, St. Louis 10, Mo.
Barber Iron Works, Inc., 301 W 61st St., P.O. Box 6318, Shreveport, La.
Barclay Mfg. Co., 1013 S Council St., Muncie, Ind.
Barium Steel Corp., 25 Broad St., New York 4, N.Y.
Barnard Foundry Co., Inc., 9 Roseland St., Springfield 7, Mass.
Barnett Foundry & Machine Co., Irvington, N.J.
Bar-Ray Products, 209 25th St., Brooklyn 32, N.Y.
Barrett Varnish Co., 1532 S 50th Court, Cicero 50, Ill.
Barrows Porcelain Enamel Corp., Langdon Farm Rd. & Penn R.R., Cincinnati 17, Ohio
Bart Mfg. Corp., 135 Manchester Pl., Newark 4, N.J.
Barth Smelting Corp., 99-129 Chapel St., Newark 5, N.J.
Bartlett-Thompson Co., Inc., 26 Water St., Wakefield, Mass.
Barton Products Corp., P.O. Box 305, West Bend, Wis.
Bassichis Co., 2323 W 3rd St., Cleveland 12, Ohio
Bassick Co., Howard Ave., Bridgeport, Conn.
Batson-Cook Co., West Point Foundry & Machine Co. Div., West Point, Ga.
Bausch & Lomb Optical Co., 98461 Bausch St., Rochester 2, N.Y.
Baxter Foundry & Machine Works, Inc., P.O. Box 1016, Boise, Id.
Bay City Electric Steel Casting Co., Trumbull St., Bay City, Mich.
Bay City Forge Co., 1802 Cranberry St., Erie, Pa.
Bay City Foundry Co., 400 Webster St., Bay City, Mich.
Bay Porous Material Co., 753 Loma Verde, Palo Alto, Calif.
Bay State Refining Co., Inc., 8 Montgomery St., Chicopee Falls, Mass.
Bay State Stamping Co., 372 Chandler St., Worcester, Mass.
Bay State Tool & Machine Co., 412 Albany, Springfield 4, Mass.
Bayley Products, Inc., 19155 Glendale Ave., Detroit 5, Mich.
Beacon Metal Mfg. Co., 1127 Atlantic Ave., Brooklyn 16, N.Y.
Bead Chain Mfg. Co., 110 Mountain Grove St., Bridgeport 5, Conn.
Bean, Morris & Co., Hyde Rd., Yellow Springs, Ohio
Bearium Metals Corp., 190 Mill St., Rochester, N.Y.
Beatty Machine & Mfg. Co., 940 150th St., Hammond, Ind.
Beaver Valley Alloy Foundry Co., Atlantic Ave., Monaco, Pa.
Beck, I. & Sons, Inc., 256 Mott St., New York 12, N.Y.
Beck Products Corp., 12255 E 8th Mile Rd., Detroit 5, Mich.
Becker Bros. Carbon Co., 3450 S Laramie Ave., Cicero 50, Ill.
Becker, L. A. Foundry Co., 1201 Hwy. 66, St. Louis 15, Mo.
Beckmann, Inc., 120 Baxter St., New York 13, N.Y.
Bee Chemical Co., 12933 S Stony Island Ave., Chicago 33, Ill.
Behringer Metal Works, Inc., 108 Jabez St., Newark 5, N.J.
Belding Corticelli Industries, 1407 Broadway, New York 18, N.Y.
Belko Corp., Kingsville, Md.
Bellaire Stove Co., 19th & Union Sts., Bellaire, Ohio
Belle City Malleable Iron Co., Racine Steel Castings Div., 1442 Forest St., Racine, Wis.
Belmet Products, Inc., 503 Morgan Ave., New York 22, N.Y.
Belmont Aluminum Extrusion Co., 1228 Belmont Ave., Philadelphia 4, Pa.
Belmont Smelting & Refining Works, 330 Belmont Ave., Brooklyn 7, N.Y.
Beloit Foundry Co., 445 Gardner St., South Beloit, Ill.
Beloit Iron Works, Rock River, Beloit, Wis.
Benada Aluminum Products Co., 37 James St., Girard, Ohio
Bendix Aviation Corp., Teterboro, N.J.
Bendix Foundries Div., Teterboro, N.J.
Eclipse-Pioneer Div., Teterboro, N.J.
Benjamin Electric Mfg. Co., Northwest Hwy., Des Plaines, Ill.
Bennett Mfg. Co., 41 Mechanic, Alden, N.Y.
Bergen Point Iron Works, 233 Broadway, New York 7, N.Y.
Bergfels, William & Co., 10 Orchard St., Newark 2, N.J.
Berry Bros., 211 Leib St., Detroit 7, Mich.
Beryl Ores Co., 12900 W 100 Ave., Arvada, Colo.
Beryllium Corp. (Ad p 157)
P.O. Box 1462, Reading, Pa.
National Precision Casting Corp. Div., P.O. Box 396, Paoli, Pa.
Bessemer Galvanizing Works, Bessemer, Ala.
Bethandale Corp., 24040 Lakeland Blvd., Cleveland 23, Ohio
Bethlehem Steel Co., 701 E 3rd St., Bethlehem, Pa.
Better Finishes & Coatings, Inc., 270 Doremus Ave., Newark, N.J.
Bettinger Corp., Gore St., Waltham, Mass.
Bevan Co., 400 N Arden Dr., El Monte, Calif.
Bickford, F. H., Co., 1529 S Broadway, Dayton 8, Ohio
Biddle Screw Products Co., S Main, Sheridan, Ind.
Bierman-Everett Foundry Co., 135 S 20th St., Irvington, N.J.
Biersach & Niedermeyer Co., 1937 N Hubbard St., Milwaukee 12, Wis.
Biggs, Carl H. Co., Inc., 1547 14th St., Santa Monica, Calif.
Bignall Co., 28 Wasson St., Buffalo 10, N.Y.
Billings & Spencer Co., 1 Laurel St., Hartford 1, Conn.
Bingham-Herbrand Corp., Herbrand Div., Lake & Stone Sts., Fremont, Ohio
Binkley Co., 100 Elm St., Warrenton, Mo.
Birchwood Chemical Co., 4500 W 44th St., Minneapolis 24, Minn.
Bird, Richard H. Co. Inc., 1 Spruce St., Waltham 54, Mass.
Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa.
Bischoff Chemical Corp., 220 Miller Rd., Hicksville, N.Y.
Bishop, J. & Co. Platinum Works, E King St., Malvern, Pa.
Bishopric Products Co., 4413 Este Ave., Cincinnati 32, Ohio
Bisonite Co., Inc., P.O. Box 84, Kenmore Sta., Buffalo 17, N.Y.
Biwax Corp., 3445 Howard St., Skokie, Ill.
Blacher, B., 752 Broadway, New York 3, N.Y.
Blacher Bros., Inc., 299 Carpenter St., Providence 9, R.I.
Black Bear Co., Inc., 44-45 23rd St., Long Island City 1, N.Y.
Black-Clawson Co., 1700 Grand Ave., Middletown, Ohio
Shartle Div., 2nd & Vine Sts., Hamilton, Ohio
Blaco Mfg. Co., 6541 Euclid Ave., Cleveland 3, Ohio
Blake & Johnson Co., Waterville 48, Conn.
Blakeslee Forging Co., Plant Pl., Plantsville, Conn.
Blank, Arthur & Co., Inc., 33 Cummington St., Boston 15, Mass.
Blaw-Knox Co., 300 6th Ave., Pittsburgh 23, Pa.
Blickman, S., Inc., 536 Gregory Ave., Weehawken, N.J.
Bliss, E. W. Co., Mackintosh-Hemphill Div., 901 Bingham St., Pittsburgh, Pa.
Bliss & Laughlin, Inc., 281 E 155th St., Harvey, Ill.
Blossom Mfg. Co., Inc., 2337 McDonald Ave., Brooklyn, N.Y.
Boatwright Paint & Varnish Works, Inc., P.O. Box 306, Norcross, Ga.
Boehm Screw Products Co., 7100 W Jefferson, Detroit 17, Mich.
Bogert & Hopper, Inc., 105 W 31st St., New York, N.Y.
Bohn Aluminum & Brass Corp., 1400 Lafayette Bldg., Detroit 26, Mich.
Bond, Charles Co., 617-623 Arch St., Philadelphia 6, Pa.
Bond International, Inc., 783 S Deacon, Detroit 17, Mich.
Bone Engineering Corp., 701 W Broadway, Glendale 4, Calif.
Bonnell, William L. Co., Inc. Newman, Ga.
Bonney-Floyd Co., 611 Marion Rd., Columbus 7, Ohio
Bonnot Co., 722 Mulberry Rd., SE, Canton 2, Ohio
Booker & Wallestad, Inc., 3336 Gorham Ave., Minneapolis 26, Minn.
Boonton Molding Co., 326 Myrtle Ave., Boonton, N.J.
Booth Felt Co., Inc., 569 18th St., Brooklyn 15, N.Y.
Boots Aircraft Nut Corp., Newtown Tpke., Norwalk, Conn.
Borden Co., Borden Chemical Co. Div., 350 Madison Ave., New York 17, N.Y.
Borg-Warner Corp., 310 S Michigan Ave., Chicago, Ill.
Atkins Saw Div., 402 S Illinois St., Indianapolis, Ind.
Franklin Steel Div., Franklin, Pa.
Ingersoll Products Div., 1000 W 120th St., Chicago 43, Ill.
Marbon Chemical Div. (Ad pp 235-242)
7165 Chicago Ave., Gary, Ind.
Borkland Mfg. Co., 803 Quarry Rd. at 900 Wabash Rd., Marion, Ind.
Bostitch, Inc., Briggs Dr., East Greenwich, R.I.
Boston Felt Co., 210 South St., Boston 11, Mass.
Boston Gear Works, 14 Hayward St., Quincy 71, Mass.
Boston Metals Co., Baldt Anchor, Chain & Forge Div., 6th & Butler Sts., Chester, Pa.
Both, O.A. Corp., 100 Nickerson Rd., Ashland, Mass.
Bound Brook Oil-Less Bearing Co., Bound Brook, N.J.
Bowling Green Rubber Co., 4143 Monroe St., Toledo 13, Ohio
Boyles Galvanizing & Plating Co., P.O. Box 187, Hurst, Texas
Bradley Paint Co., 608 W Crawford Ave., Connellsville, Pa.
Bradley & Vrooman Co., 2629 S Dearborn St., Chicago 16, Ill.
Braeburn Alloy Steel Corp., Braeburn, Pa.
Brandt, Charles T. Inc., 1700 Ridgely St., Baltimore 30, Md.
Brasco Mfg. Co., Harvey, Ill.
Brewer-Titchener Corp., 111 Port Watson St., Cortland, N.Y.
Bridgeport Brass Co. (Ad p 176)
30 Grand St., Bridgeport 2, Conn.
Cored Forging Div., P.O. Box 119, South Norwalk, Conn.
Hunter-Douglas Aluminum Div., 3016 Kansas Ave., Riverside, Calif.
Bridgeport Moulded Products, Inc., 105 Meadow St., Fairfield, Conn.
Bridgeport Rolling Mills Co., Bridgeport, Conn.
Briel Industries, Inc., 2232 E Market St., New Albany, Ind.
Briggs-Shaffner Co., 500 Brookstown Ave., Winston-Salem, N.C.
Brinkerhoff Brass & Bronze Works, Inc., 57½ Dey St., New York 7, N.Y.
Bristol Brass Corp., 580 Broad St., Bristol, Conn.
Accurate Brass Corp. Sub., Pine & Emmett Sts., Bristol, Conn.
Broadway Mfg. Co., P.O. Box 252, Springdale Rd., Waukesha, Wis.
Broadway Rubber Corp., 728 S 13th St., Louisville, Ky.
Brockway Pressed Metals, Inc., 921 Clark St., Brockway, Pa.
Brom Machine & Foundry Co., 3565 6th St., Winona, Minn.
Bronze & Steel Die Casting Co., Plano, Ill.
Brooks & Perkins, Inc. (Ad p 457)
1950 W Fort St., Detroit 16, Mich.
Brown Corp., 213 Bellevue Ave., Syracuse 1, N.Y.
Brown Rubber Co., Inc., P.O. Box 1000, Lafayette, Ind.
Bruce Foundry & Mfg. Co., 4040 S Evans St., Tecumseh, Mich.
Brunswick Corp., Marion, Va.
Defense Products Div., 1700 Messler St., Muskegon, Mich.
Brush Beryllium Co. (Ad p 171)
4301 Perkins Ave., Cleveland 3, Ohio
Pennrold Div., 501 Crescent Ave., Reading, Pa.
Buchmann Spark-Wheel Corp., 4-20 47th Ave., Long Island City 1, N.Y.
Buckeye Brass & Mfg. Co., 6410 Hawthorne Ave., Cleveland 3, Ohio
Buckeye Iron & Brass Works, 324 E 3rd St., Dayton 1, Ohio
Buckeye Molding Co., 213 S 3rd St., Miamisburg, Ohio
Buffalo Steel Corp., Tonawanda, N.Y.
Buffalo Wire Works Co., 320 Terrace, Buffalo 2, N.Y.
Bullock, W.J. Inc., P.O. Box 539, Fairfield, Ala.
Bundy Tubing Co., 8109 E Jefferson, Detroit 14, Mich.
Bunker Hill Co., 660 Market St., San Francisco 4, Calif.
Bunting Brass & Bronze Co., 715 Spencer, Toledo 1, Ohio
Burgess-Norton Mfg. Co., 737 Peyton St., Geneva, Ill.
Burkhardt Steel Co., 869 S Broadway, Denver 9, Colo.
Burwood Products Co., Airport Dr., Traverse City, Mich.
Busada Mfg. Corp. (Ad p 442)
32-21 Downing St., Flushing, N.Y.
Busch, J.C. Co., 17 W 54th St., New York 19, N.Y.
Butler Engine & Foundry Co., Inc., 151 S Monroe, Butler, Pa.
Butler Mfg. Co., 7309 E 13th St., Kansas City, Mo.

Addresses of Suppliers

Button Corp. of America, 49 Dickerson St., Newark 9, N.J.
Byers, A. M., 1810 Clark Bldg., Pittsburgh 22, Pa.
Byrd Plastics, Inc., 2953 W 12th St., Erie, Pa.

C

C. E. M. Co., 3 School St., Danielson, Conn.
CFI Corp., Cottage Pl., Mineola, N.Y.
C & G Screw Machine Products Co., P.O. Box 308, Carmel, Ind.
Cadillac Malleable Iron Co., 10th St., Cadillac, Mich.
Cadillac Plastic & Chemical Co., 15111 2nd Ave., Detroit, Mich.
Caldwell, W. E. Co., 2020 Brook St., Louisville 8, Ky.
Calfibe Co., Inc., P.O. Box 832, Redlands, Calif.
California Drop Forge Co., 1033 Alhambra Ave., Los Angeles 12, Calif.
California Metal Enameling Co., 6904 E Slauson Ave., Los Angeles 22, Calif.
California Perforated Screen Co., 345-347 Folsom St., San Francisco 5, Calif.
Callahan Zinc-Lead Co., Inc., Flexaust Div., 100 Park Ave., New York 17, N.Y.
Calorizing Co., P.O. Box 8742, Pittsburgh 21, Pa.
Calumet & Hecla, Inc., 13 Calumet Ave., Detroit 9, Mich.
Calumet Div., 11 Calumet Ave., Calumet, Mich.

Wolverine Tube Div. (Ad p 445)
1439 Central Ave., Detroit 9, Mich.

Calumet Steel Castings Corp., 1636 Summer St., Hammond, Ind.
Cambridge Wire Cloth Co., Cambridge, Md.
Camcar Screw & Mfg. Co., 600 18th Ave., Rockford, Ill.

Cameron Iron Works, Inc., Special Products Div. (Ad p 439)
P.O. Box 1212, Houston 1, Tex.

Camfield Fiberglass Plastics, Inc., N Centennial St., Zeeland, Mich.
Camloc Fastener Corp., 22 Spring Valley Rd., Paramus, N.J.
Campro Co., 3131 Alliance Rd., NE, Canton 1, Ohio
Canfield, H.O. Co., Box 529, Clifton Forge, Va.
Cannon-Muskegon Corp., 2875 Lincoln St., Muskegon, Mich.
Canton Malleable Iron Co., 2408 13th NE, Canton, Ohio
Capac Mfg. Corp., Capac, Mich.
Capitol Chemical Co., 4501 W Haddon Ave., Chicago 51, Ill.
Capitol Products Corp., Mechanicsburg, Pa.
Carbo Tool & Die Co., 219 Howland St., Fremont, Ohio
Carboline Co., 32 Hanley Ct., St. Louis 17, Mo.
Carbone Corp., 400 Myrtle Ave., Boonton, N.J.
Carborundum Co., Niagara Falls, N.Y.
Refractories Div., Perth Amboy, N.J.
Carborundum Metals Co., P.O. Box 32, Akron, N.Y.
Carey, Philip Mfg. Co., 320 S Wayne Ave., Lockland, Cincinnati 15, Ohio
Carleton Screw Products Co., 2424 Hiawatha Ave S, Minneapolis 4, Minn.
Carlon Products Corp., 10225 Meech Ave., Cleveland 5, Ohio
Carlson, G.O. Inc., Thorndale, Pa.
Carolina Asbestos Co., Davidson, N.C.
Carondelet Foundry Co., 2101 S Kingshighway, St. Louis 10, Mo.
Carpenter Steel Co., 101 W Bern St., Reading, Pa.
Alloy Tube Div., Springfield Rd., Union, N.J.
Webb Wire Div., 17 Liberty St., New Brunswick, N.J.
Carroll, J.B. Co., 319 N Albany Ave., Chicago 12, Ill.
Carroll Pressed Metal, Inc., 133 Dewey St., Worcester 10, Mass.
Cartwright, R. Tube Products Co., 609 St. Jean Ave., Detroit 14, Mich.
Case, J. I. Co., 702 State St., Racine, Wis.
Caspers Tin Plate Co., 4100 W 42nd Pl., Chicago 32, Ill.
Cast Optics Corp., Room 8, 123 Newman St., Hackensack, N.J.
Castalloy Co., Inc., W Central St., Natick, Mass.
Casting Engineers, Inc., 2323 N Bosworth, Chicago, Ill.
Casting Service Corp. of Michigan, Mathien Ave., Bridgman, Mich.
Castle, A M. & Co., 3400 N Wolf Rd., Franklin Park, Ill.
Castle Rubber Co., P.O. Box 589, Butler, Pa.
Catalin Corp. of America, 1 Park Ave., New York 16, N.Y.
Ceilcote Co., 4832 Ridge Rd., Cleveland 9, Ohio

Celanese Corp. of America. Celanese Plastics Co. Div. (Ad pp 271-274)
744 Broad St., Newark 2, N.J.

Celluplastic Corp., 50 Ave. L, Newark 5, N.J.

Cellusuede Products, Inc. (Ad p 363)
511 N Madison St., Rockford, Ill.

Celotex Corp., 120 S LaSalle St., Chicago 3, Ill.
Central Fabricators, Inc., 408 Poplar St., Cincinnati, Ohio
Central Felt & Fabrics Corp., 24 W 25th St., New York 10, N.Y.
Central Screw Co., 3501 S Shields, Chicago 9, Ill.
Central Screw Products Co., 284 Walker St., Detroit 7, Mich.
Centrifugal Casting Co., 3245 Cherry Ave., Long Beach 7, Calif.
Centrifugal Casting Co., 147 W 42nd St., New York 36, N.Y.
Centrifugal Casting Machine Co., P.O. Box 947, Tulsa 1, Okla.
Centr-O-Cast & Engineering Co., 45 South St. & St. Jean Ave., Detroit 14, Mich.
Century Die Casting Co., 2629 W Fletcher St., Chicago 18, Ill.
Ceromet, Inc., 16233 Gale Ave., Industry, Calif.

Cerro de Pasco Sales Corp. (Ad p 178)
300 Park Ave., New York 22, N.Y.
Lewin-Mathes Div., 1111 Chouteau Ave., St. Louis 2, Mo.

Chace, W.M. Co., 1600 Beard Ave., Detroit 9, Mich.
Chain Belt Co., 4701 W Greenfield Ave., Milwaukee 1, Wis.
Chambersburg Engineering Co., Derbyshire St., Chambersburg, Pa.
Champion Rivet Co., Harvard Ave. & E 108th St., Cleveland 5, Ohio
Chandler Products Corp., 1491 Chardon Rd., Cleveland 17, Ohio
Channel Master Corp., Ellenville, N.Y.
Chapman Machine Co., Inc., 41 Main St., Terryville, Conn.
Chardon Metal Products Co., Mill St., Chardon, Ohio
Chardon Rubber Co., 6th & Washington Aves., Chardon, Ohio
Charlotte Leather Belting Co., 209 E 12th St., Charlotte 1, N.C.
Char-Lynn Co., Diecasting Div., 2843 26th Ave. S, Minneapolis 6, Minn.
Chattanooga Aluminum Foundry, Inc., 2000 Chestnut St., Chattanooga 8, Tenn.
Chemetron Corp., Tube Turns Div., 224 E Broadway, Louisville 1, Ky.

Chemical Corp. (Ad p 360)
67 Waltham Ave., Springfield 9, Mass.

Chemical Coatings Corp., Dividend Rd., Rocky Hill, Conn.
Chemical Coatings & Engineering Co., Inc., 221 Brooke St., Media, Pa.
Chemical Development Corp., Endicott St., Danvers, Mass.
Chemical Process Co., 1901 Spring St., Redwood City, Calif.
Chemical Products Corp., King Philip Rd., East Providence 14, R.I.
Chemore Corp., 2 Broadway, New York 4, N.Y.
Chemtrol, 404 W St. Anne Pl., Santa Ana, Calif.
Chemung Foundry Corp., Elmira, N.Y.
Chicago Aluminum Castings, 2647 Ogden Ave., Chicago, Ill.
Chicago Bridge & Iron Co., 332 S Michigan Ave., Chicago 4, Ill.
Chicago Development Corp., 5810 47th Ave., Riverdale, Md.
Chicago Extruded Metals Co., 1642 S 54th Ave., Cicero 9, Ill.
Chicago Gasket Co., 1271 W North Ave., Chicago 22, Ill.
Chicago Hardware Foundry Co., 2600 Commonwealth Ave., North Chicago, Ill.
Chicago Malleable Castings Co., 1225 W 120th St., Chicago 43, Ill.
Chicago Molded Products Corp., 1050 N Kolmar Ave., Chicago 35, Ill.

Campco Div. (Ad p 243)
2736 N Normandy Ave., Chicago 35, Ill.

Custom Molding Div., 1020 N Kolmar Ave., Chicago 51, Ill.
Chicago Powdered Metal Products Co., Schiller Park, Ill.
Chicago Rawhide Mfg. Co., 1301 Elston Ave., Chicago 22, Ill.
Chicago Rivet & Machine Co., 950 S 25th Ave., Bellwood, Ill.
Chicago Rubber Co., Inc., 653 Market St., Waukegan, Ill.
Chicago Smelting & Refining Corp., 3701 S Kedzie Ave., Chicago 32, Ill.
Chicago Steel Service Co., 4444 S Kildare Ave., Chicago 32, Ill.
Chicago Thrift-Etching Corp., 1555 N Sheffield Ave., Chicago 22, Ill.
Chicago White Metal Casting, Inc., 5239 W Grand Ave., Chicago 39, Ill.
Chicago-Allis Mfg. Corp., 113-125 N Green St., Chicago 7, Ill.
Chicopee Mills, Inc., 47 Worth St., New York 13, N.Y.
Lumite Div., 47 Worth St., New York 13, N.Y.
Chippewa Plastics Co., 1701 1st Ave., Chippewa Falls, Wis.
Chromalloy Corp., 450 Tarrytown Rd., White Plains, N.Y.
Elyria Foundry Div., Elyria, Ohio
Sintercast Div., 134 Woodworth Ave., Yonkers 2, N.Y.
Chromium Corp. of America, 100 Park Ave., New York 17, N.Y.
Chromizing Corp., 4609 Staunton Ave., Los Angeles 58, Calif.
Chrysler Corp., P.O. Box 1687, Detroit 31, Mich.
Amplex Div., P.O. Box 2718, Detroit 31, Mich.
Cycleweld Div., 5437 W Jefferson, Trenton, Mich.
Ciba Co., Inc., 622 Greenwich St., New York 14, N.Y.

Plastics Div. (Ad pp 278-279)
Kimberton, Pa.

Cincinnati Forging Co., 5604 Booster Pike, Cincinnati, Ohio
Cincinnati Foundry Co., 238 W Mitchell Ave., Cincinnati 32, Ohio
Cincinnati Industries Inc., 515 Station Ave., Cincinnati 15, Ohio
City Plating Works, Inc., 905 Honeyspot Rd., Stratford, Conn.

Clad-Rex Corp. (Ad p 413)
2101 S. Indiana, Chicago 16, Ill.

Clapp, E. D. Mfg. Co., Inc., 505 Genesee St., Auburn, N.Y.
Clark Bros. Bolt Co., Milldale, Conn.
Clark Perforating Co., 15875 Allen Rd., Milan, Mich.
Clarksville Foundry & Machine Works, Commerce & Spring Sts., Clarksville, Tenn.
Clayton & Lambert Mfg. Co., 1701 Dixie Hwy., Louisville 10, Ky.
Clayton Mark & Co., 1900 Dempster St., Evanston, Ill.
Clendenin Bros., Inc., 4309 Erdman Ave., Baltimore 13, Md.
Cleveland Cap Screw Co., 4444 Lee Rd., Cleveland 28, Ohio
Cleveland City Forge Co., 1621 Euclid Ave., Cleveland 15, Ohio
Cleveland Electro Metals Co., 2391 W 38th St., Cleveland 13, Ohio
Cleveland Foundry & Mfg. Co., Inc., 685 6th St., NE, Cleveland, Tenn.
Cleveland Graphite Bronze Co., 17044 St. Clair Ave., Cleveland 10, Ohio
Cleveland Hard Facing Co., Inc., 3047 Stillson Ave., Cleveland 5, Ohio
Cleveland Metal Products Co., Washington & Center Sts., Cleveland 13, Ohio
Cleveland Porcelain Enameling Co., 3190 E 65th St., Cleveland 27, Ohio
Cleveland Pressed Products Corp., 6712 Union Ave., Cleveland 5, Ohio
Cleveland Steel Specialty Co., Inc., 3765 E 91st St., Cleveland 5, Ohio
Cleveland Tungsten, Inc., 10200 Meech Ave., Cleveland 5, Ohio
Cleveland Wire Cloth & Mfg. Co., 3573 E 78th St., Cleveland 5, Ohio
Cliff Mfg. Co., 30240 Lakeland Blvd., Wickliffe, Ohio
Clifton Conduit Corp., 3300 Eastbourne Ave., Baltimore 24, Md.
Clinton Co., 1216 Elston Ave., Chicago 22, Ill.
Clinton Metal Products Co., 1076 W Locust St., Wilmington, Ohio
Clopay Corp., Clopay Sq., Cincinnati 14, Ohio
Closures, Inc., 46 State St., Waterbury, Conn.
Clover Industries, Inc., 578-588 Young St., Tonawanda, N.Y.
Cly-Del Mfg. Co., Inc., Box 1367, Waterbury, Conn.
Coast Mfg. & Supply Co., P.O. Box 71, Livermore, Calif.
Coast Pro-Seal & Mfg. Co., 2235 Beverly Blvd., Los Angeles 57, Calif.
Coated Abrasive Products, Inc., 30208 Lakeland Blvd., Wickliffe, Ohio
Coated Coil Corp., 513 W 30th St., New York 1, N.Y.

Coating Products, Inc. (Ad p 359)
101 W Forest Ave., Englewood, N.J.

Cochran Foil Co., 1430 S 13th St., Louisville, Ky.

In contacting suppliers, please mention the Materials Selector Issue

Cochrane Foundry, Inc., Box 749, York, Pa.

Cohan Epner Co., Inc., 142 W 14th St., New York 11, N.Y.

Coil Anodizers, Inc., 1250 Keating Ave., Muskegon, Mich.

Cole-Roscoe Mfg. Co., 55 Bates Ct., South Norwalk, Conn.

Collis Co., Clinton, Iowa

Colonial Alloys Co., Ridge Ave. & Crawford St., Philadelphia 29, Pa.

Colonial Art Co., Inc., Crane Ave., Westfield, Mass.

Colonial Kolonite Co., 2232 Armitage Ave., Chicago 47, Ill.

Colonial Plastics Mfg. Co., 2685 E 79th St., Cleveland 4, Ohio

Colorado Fuel & Iron Corp., Continental Oil Bldg., Denver 2, Colo.
Pacific Coast Div., 1080 19th Ave., Oakland 6, Calif.
Roebling's, John A. Sons Div., 640 S Broad St., Trenton 2, N.J.
Wickwire Spencer Steel Div., 575 Madison Ave., New York 22, N.Y.

Colt's Plastics Co., Inc., P.O. Box 96, North Grosvenordale, Conn.

Columbia Metal Stamping Co., 11900 Harvard Ave., Cleveland 5, Ohio

Columbia Steel & Shafting Co., Sumerill Tubing Co. Div., P.O. Box 1557, Pittsburgh 30, Pa.

Columbia Tool Steel Co., Lincoln Hwy. & State St., Chicago Heights, Ill.

Columbian Bronze Corp., 216 N Main St., Freeport, N.Y.

Columbian Steel Tank Co., 1509 W 12th St., Kansas City 1, Mo.

Columbiana Pump Co., Columbiana, Ohio

Columbia-National Corp., 1 Gateway Center, Pittsburgh 22, Pa.

Columbus Bolt & Forging Co., 291 Marconi Blvd., Columbus 15, Ohio

Columbus Coated Fabrics Corp., 7th & Grant Aves., Columbus 16, Ohio

Columbus Dental Mfg. Co., 634 Wager St., Columbus 6, Ohio

Columbus Jack Corp., 2200 S Third St., Columbus 7, Ohio

Columbus Production Mfg. Co., 1559 McKinley, Columbia, Ohio

Combined Industries Co., P.O. Drawer 431, Catskill, N.Y.

Combustion Engineering, Inc., 1318 N Branch St., Chicago 22, Ill.

Comco Plastics, Inc., 98-34 Jamaica Ave., Richmond Hill, N.Y.

Comerford Mfg. Co., Inc., 81 Farmington Ave., Bristol, Conn.

Comet Metal Products Co., Inc., 91-04 132nd St., Richmond Hill 18, N.Y

Commercial Chemical Co., 1021 Summer St., Cincinnati 4, Ohio

Commercial Iron Works, 2424 Porter, Los Angeles, Calif.

Commercial Plastics Co., 2810 W North Ave., Chicago 47, Ill.
Associated Plastic Div., 400 E Hines St., Midland, Mich.

Commercial Plastics & Supply Corp., 630 Broadway, New York 12, N.Y.

Commercial Screw Products Co., 15105 Darwin Ave., Cleveland 10, Ohio

Commercial Shearing & Stamping Co., 1775 Logan Ave., Youngstown, Ohio

Commercial Steel Casting Co., Cheney Ave., Marion, Ohio

Commercialores, Inc., Box 98, Clover, S.C.

Compacted Metals Corp., 99 Greenwood Ave., Waukegan, Ill.

Composite Forgings, Inc., 2300 W Jefferson Ave., Detroit 16, Mich.

Composite Industrial Metals, Inc., 235 Georgia Ave., Providence 5, R.I.

Compton Foundry, Compton, Calif.

Concord Mica Corp., 26 Crescent, Penacook, N.H.

Condamatic Co., Inc., 2700 E 9 Mile Rd., Hazel Park, Mich.

Conforming Matrix Corp., 12th & Woodruff Sts., Toledo 2, Ohio

Conn Perry Mfg. Co., 4341 Horatio Ave., Detroit 10, Mich.

Conneaut Die Casting Co., 618 Sandusky St., Conneaut, Ohio

Connecticut Hard Rubber Co., 407 East St., New Haven 9, Conn.

Connecticut Malleable Castings Co., New Haven 6, Conn.

Connecticut Mfg. Co., 115 Benedict St., Waterbury 20, Conn.

Connell Asbestos Mfg. Co., 117 Martense St., Brooklyn 26, N.Y.

Conner Mfg. Co., 828 S 17th St., Louisville, Ky.

Consolidated Foundries & Mfg. Corp., Michigan Steel Casting Co. Div., 1999 Guoin St., Detroit 7, Mich.

Consolidated Fruit Jar Co., 62 Water St., P.O. Box 109, New Brunswick, N.J.

Consolidated Industries, Inc., Mixville Rd., West Cheshire, Conn.

Consolidated Iron-Steel Mfg. Co., Ackerman Plastic Molding Div., 986 E 200th St., Cleveland 19, Ohio

Consolidated Molded Products Corp., 1940 Thomas St., Scranton, Pa.

Consolidated Vacuum Corp., 1775 Mt. Read Blvd., Rochester 3, N.Y.

Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis.

Consoweld Corp., 700 Hooker St., Wisconsin Rapids, Wis.

Continental Boiler & Sheet Iron Works, 5603 W Park Ave., St. Louis, Mo.

Continental Can Co., 100 E 42nd St., New York 17, N.Y.
Conolite Div., 205 W 14th St., Wilmington, Del.
Flexible Packaging Div., Mount Vernon, Ohio

Continental Coatings Corp., 17706 Miles Ave., Cleveland, Ohio

Continental Copper & Steel Industries, Inc., 345 Madison Ave., New York 17, N.Y.
Niagara Falls Smelting & Refining Div., 2200-2214 Elmwood Ave., Buffalo 23, N.Y.

Continental Die Casting Corp., 9615 Grinnell Ave., Detroit 13, Mich.

Continental Felt Co. (Ad p 322)
26 W 15th St., New York 11, N.Y.

Continental Gin Co., Birmingham, Ala.

Continental Rubber Works, 1985 Liberty St., Erie 6, Pa.

Continental Screw Co., 459 Mt. Pleasant St., New Bedford, Mass.

Continental Steel Corp., 1109 S Main St., Kokomo, Ind.

Continental Wire & Iron Works, Continental Nu-Steel Metal Products Div., 1249 S Ashland Ave., Chicago 8, Ill.

Continental-Diamond Fibre Corp., Newark, Del.

Continental-Emsco Co., P.O. Box 2098, Terminal Annex, Los Angeles 54, Calif.

Contour Extrusion Co., 517 Fayette Ave., Mamaroneck, N.Y.

Control Parts Corp., 530 Burnside Ave., Inwood 96, L.I., N.Y.

Conversion Chemical Corp., 98 E Main St., Rockville, Conn.

Cooley, W.J. & Co., P.O. Box 1471, 107 Hernando, Memphis, Tenn.

Cooper Alloy Corp., Bloy St. & Ramsey Ave., Hillside 5, N.J.

Cooper, Peter Corp., Palmer St., Gowanda, N.Y.

Cooper-Bessemer Corp., Mt. Vernon, Ohio

Coors Porcelain Co., 600 9th St., Golden, Colo.

Co-Polymer Chemicals Inc., 12350 Merriman Rd., Livonia, Mich.

Copolymer Rubber and Chemical Corp., P.O. Box 2591, Baton Rouge 1, La.

Copper and Brass Sales, Inc., 6555 E Davison St., Detroit 12, Mich.

Copper Range Co., Hussey, C.G. & Co. Div. (Ad p 180)
2850 2nd Ave., Pittsburgh 19, Pa.

Copperweld Steel Co., Warren, Ohio
Aristoloy Steel Div., Mahoning Ave. Ext., Warren, Ohio
Ohio Seamless Tube Div., Shelby, Ohio
Superior Steel Div., Superior St., Carnegie, Pa.

Cordo Chemical Corp. (Ad p 269)
34 Smith St., Norwalk, Conn

Cordo Molding Products, Inc. (Ad p 269)
34 Smith St., Norwalk, Conn.

Corite Products, Inc., 6553 W George St., Chicago 34, Ill.

Cornell and Underhill, Inc., 1310 Jefferson St., Hoboken, N.J.

Corning Glass Works (Ad p 319)
Corning, N. Y.

Corson Industries, 1228 Belmont Ave., Philadelphia 4, Pa.

Cosmo Plastics Co., 3239 W 14th St., Cleveland 9, Ohio

Couch-Uthe Co., 140 S Olive St., Elyria, Ohio

Coyne & Paddock, Inc., 40-09 21st St., Long Island City 1, N.Y.

Craft Mfg. Co., 2301 Davis St., North Chicago, Ill.

Craft Metal Spinning Co., 302 E Main St., Dundee, Ill.

Craftint Mfg. Co., 1615 Collamer Ave., Cleveland 10, Ohio

Crane Co., 836 S Michigan Ave., Chicago 5, Ill.
Metals Div., 4461 Bridge St., Johnstown, Pa.

Crane Packing Co., 6400 Oakton St., Morton Grove, Ill.

Crane Plastics, Inc. (Ad p 464)
500 Hutton Pl., Columbus 15, Ohio

Crawford & Doherty Foundry Co., 4604 SE 17th Ave., Portland, Ore.

Crescent Bronze Powder Co., 116 W Illinois St., Chicago 10, Ill.

Crescent Co., Inc., Carol Cable Co. Div., 90 Middle St., Pawtucket, R.I.

Crescent Plastics, Inc., 955 Diamond Ave., Evansville 7, Ind.

Crest Chemical Industries Corp., 132-34 32nd Ave., Flushing, N.Y.

Crobalt, Inc., 2800 S State St., Ann Arbor, Mich.

Croname, Inc., 6275 Howard St., Chicago 48, Ill.

Crosby Co., 183 Pratt St., Buffalo 4, N.Y.

Cross Engineering Co., Carbondale, Pa.

Crown Metal Co., 121 E Washington St., Milwaukee 4, Wis.

Crown Non-Ferrous Foundry, Inc. Concord Ave., Chester, Pa.

Crucible Steel Co. of America (Ad p 93)
P.O. Box 2518, Pittsburgh 30, Pa.
Titanium and Vacuum Metal Products Div., P.O. Box 2518, Pittsburgh 30, Pa.
Trent Tube Co., P.O. Box 2518, Pittsburgh 30, Pa.

Crucible Steel Casting Co., Union Ave. & Penn R.R., Lansdowne, Pa.

Cruver Mfg. Co., 2460 W Jackson, Chicago 12, Ill.

CrystalX Corp., W Lenni Rd., Lenni Mills, Pa.

Cumberland Steel Co., 101 Williams St., Cumberland, Md.

Curbell, Inc., 777 Hertel Ave., Buffalo 7, N.Y.

Curtis Cos., Inc., American Plywood Div., New London, Wis.

Curtis Products Co., 7 Cherry Ave., Waterbury 4, Conn.

Curtis Screw Co., Inc., 19 Gull St., Buffalo 13, N.Y.

Curtiss-Wright Corp., 304 Valley Blvd., Wood-Ridge, N.J.
Metals Processing Div., 706 Northland Ave., Buffalo 15, N.Y.
Plastics Div., 50 Rockefeller Plaza, New York, N.Y.
Utica Div., 50500 Mound Rd., Utica, Mich.

Custom Tool and Mfg. Co., 2201 N 2nd St., Minneapolis 11, Minn.

Cuyahoga Stamping Co., 10201 Harvard Ave., Cleveland 5, Ohio

Cyril Bath Co., 32342 Aurora Rd., Solon, Ohio

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DK Mfg. Co., Cobra Metal Hose Div., 5059 S Kedzie Ave., Chicago 32, Ill.

Dacar Chemical Products Co., 1007 McCartney St., Pittsburgh, Pa.

Dahlin, C. A. Co., 2727 Clybourn Ave., Chicago 14, Ill.

Dalton Foundries, Inc., Lincoln & Jefferson Sts., Warsaw, Ind.

Damascus Tube Co., P.O. Box 71, Greenville, Pa.

Dana Corp., Bennett Rd. & Sylvania Ave., Toledo 1, Ohio
Auburn Div., Auburn, Ind.
Parish Pressed Steel Div., Box 1422, Reading, Pa.

Danby Mfg. Co., Portland, Mich.

Danielson Mfg. Co., Lee St., Danielson, Conn.

Dapol Plastics, Inc., 53 Northboro St., Worcester 4, Mass.

Darby Corp., 1st & Walker Sts., Kansas City 15, Kan.

Dare Products, Inc., 860 Betterly Rd., Battle Creek, Mich.

Darling, L. A., Midwest Foundry Co. Div., 66-76 Clark St., Coldwater, Mich.

Darling Valve & Mfg. Co., Walnut & Marshall Sts., Williamsport, Pa.

Darlington Veneer Co., 4th St., Darlington, S.C.

Daubert Chemical Co., 333 N Michigan Ave., Chicago, Ill.

Davidson Rubber Co., 50 Brighton St., Charlestown 29, Mass.

Davis & Hemphill, 2000 Furnace Ave., Elkridge 27, Md.

Davis, Joseph Plastics Co., Kearny, N.J.

Davis Products Corp., 601 39th St., Brooklyn 32, N.Y.

Dawlen Corp., 1911 Fargo Rd., Jackson, Mich.

Day Co., 810 3rd Ave., NE, Minneapolis 13, Minn.

Day, James B. & Co., 1872 Clybourn Ave., Chicago 14, Ill.

Dayton Bronze Bearing Co., 111 Front St., Dayton 2, Ohio

Dayton Foundry, 11803 Industrial Ave., Hollydale, Calif.

Dayton Malleable Iron Co., P.O. Box 980, Dayton 1, Ohio
G. H. R. Div., 400 Detrick St., Dayton 1, Ohio
Ironton Malleable Div., Ironton, Ohio
Meta-Mold Aluminum Co., 525 E Hamilton Rd., Cedarburg, Wis.
Ohio Malleable Div., Box 88, Sta. A, Columbus, Ohio
Pratt & Letchworth Div., 189 Tonawanda St., Buffalo 7, N.Y.

Dayton Rogers Mfg. Co., 2824 13th Ave., S, Minneapolis 7, Minn.

Dayton Rubber Co., Dayton 1, Ohio
Molded Products Div., P.O. Box 209, Three Rivers, Mich.

Dayton Steel Foundry Co., 1366 Miami Chapel Rd., Dayton 1, Ohio

Dearborn Stamping Co., 10501 Haggerty Ave., Dearborn, Mich.

Debevoise Co., 74 20th St., Brooklyn 32, N.Y.

Decatur Automatic Co., P.O. Box 26, Warrensburg, Ill.

Decatur Casting Co., 822 Dayton Ave., Decatur, Ind.

Decrow Engineering Corp., Main St., Middleport, N.Y.
Deerfield Mfg. Co., 4th Ave., Mason, Ohio
Defiance Metal Products Co., 21 Seneca St., Defiance, Ohio
Defiance Stamping Co., Perry & German Sts., Defiance, Ohio
De Laval Steam Turbine Co., 853 Nottingham Way, Trenton 2, N.J.
Delaware Tool Steel Corp., 34th & Market Sts., Wilmington, Del.
Delo Screw Products Co., 38 S Franklin St., Delaware, Ohio
Delron Co., Inc., 5224 Southern Ave., South Gate, Calif.
Delta Plastics Co., 776 Creek Rd., Bellmawr, N.J.
Delta Plywood Corp., Cotton Plant, Ark.
Dennis Chemical Co., 2701 Papin St., St. Louis 3, Mo.
Denver Plastics, Inc., 15200 W Colfax Ave., Golden, Colo.
Dependable Automatic Screw Co., 282 S Lenard St., Waterbury 20, Conn.
Derby Castings Co., 593 N Main St., Seymour, Conn.
Deringer Metallurgical Corp., 8131 Monticello Ave., Skokie, Ill.
De Sanno Foundry & Machine Co., 1919 Peralta St., Oakland 7, Calif.
Designers Metal Corp., 469 E 159th St., Harvey, Ill.
De Soto Paint & Varnish Co., P.O. Box 186, Garland, Tex.
Detrex Chemical Industries, Inc., Box 501, R P K Annex 32, Detroit, Mich.
Detroit Brass & Malleable Co., 2968 7th St., Wyandotte, Mich.
Detroit Float & Stamping Co., 625 Monroe St., Detroit, Mich.
Detroit Gasket & Mfg. Co., Extruded Metals Div., 12640 Burt Rd., Detroit 23, Mich.
Detroit Macoid Corp., 12340 Cloverdale, Detroit 4, Mich.
Detroit Stamping Co., 350 Midland St., Detroit 3, Mich.
Detroit Steel Corp., Portsmouth Div., Detroit 9, Mich.
Deuscher, H.P. Co., 7th & Hanover Sts., Hamilton, Ohio
Devcon Corp., Danvers, Mass.
Devoe & Raynolds Co., Inc., Jones-Dabney Co. Div., 1481 S 11th St., Louisville 8, Ky.
Dexter, C.H. & Sons, Inc., Windsor Locks, Conn.
Diamond Alkali Co., 300 Union Commerce Bldg., Cleveland 14, Ohio
Diamond Lumber Co., 323 Pittock Block, Portland 5, Ore.
Diamond Mfg. Co., W 8th St., Wyoming, Pa.
Diamonite Products Mfg. Co., Shreve, Ohio
Die Cast Products, Inc., 621 W Rosecrans Ave., Gardena, Calif.
Diecast Corp., 522-524 Hupp Ave., Jackson, Mich.
Dietzel Lead Burning Co., Narrows Run Rd., Coraopolis, Pa.
Dimco-Gray Co., 207 E 6th St., Dayton 2, Ohio
Dip Seal Plastics, Inc., 2311 23rd Ave., Rockford, Ill.
Dirilyte Co. of America, Inc., 1142 S Main St., Kokomo, Ind.
Dixogrin Industries, Inc., 510 S Fulton Ave., Mount Vernon, N.Y.
Diversey Corp., Metal Industries Div., 1820 Roscoe St., Chicago 13, Ill.
Division Lead Co., 7742 W 61st Pl., Summit, Ill.
Dixie Aluminum Corp., 304 E 2nd Ave., Rome, Ga.
Dixie Bronze Co., P.O. Box 1148, Birmingham 1, Ala.
Dixie Galvanizing & Tank Co., 1901 McQuade St., Jacksonville, Fla.
Dixie Lead Co., Sargent Rd., Box 8625, Dallas 16, Tex.
Dixie Plastics Mfg. Co., 3017 N Galves St., New Orleans, La.
Dixon Corp., Burnside St., Bristol, R.I.
Dixon Sintaloy, Inc. (Ad p 434)
535 Hope St., Stamford Conn.
Dodge Fibers Corp., John St., Hoosick Falls, N.Y.
Dodge Mfg. Corp., 500 S Union St., Mishawaka, Ind.
Dodge Steel Co., 6501 State Rd., Philadelphia 35, Pa.
Dolin Metal Products, Inc., 315 Lexington Ave., Brooklyn 16, N.Y.
Dollin Corp., 650 S 21st St., Irvington 11, N.J.
Donegal Steel Foundry Co., 601 E Market St., Marietta, Pa.
Donovan, F. C. Inc., 192 South St., Boston, Mass.
Dormont Mfg. Co., 5607 Butler St., Pittsburgh 1, Pa.
Dostal Foundry & Machine Co., Box 180, Pontiac, Mich.
Douglas Aircraft Co., Inc., Aircomb Div., 1720 Pico Blvd., Santa Monica Calif.
Douglas & Sturgess, 475 Bryant St., San Francisco 7, Calif.
Dow Chemical Co., Midland, Mich.
Dobeckmun Co. Div., 3301 Monroe Ave., Cleveland 13, Ohio
Dow Metal Products Co. Div. (Ad pp 408-409)
Midland Mich.
Plastics Div., Midland, Mich.
Dow Corning Corp., Midland, Mich.
Downer, Hunnewell, Inc., Mono-Seal Products Div., 44 Garden St., Everett 49, Mass.
Downington Iron Works, 161 Wallace St., Downington, Pa.
Dravo Corp., 102 5th Ave., Pittsburgh 22, Pa.
Drawn Metal Tube Co., 101 Elm St., Thomaston, Conn.
Dresser Industries, Inc., Dresser Mfg. Div., 43 Fisher Ave., Bradford, Pa.
Dresser Operations, Inc., Clark Bros. Co. Div., Lincoln Ave. & 5th St., Olean, N.Y.
Drexel Screw Products Co., 6200 S Oakley Ave., Chicago 36, Ill.
Driver, Wilbur B. Co. (Ad p 185)
1875 McCarter Hwy., Newark 4, N.J.
Western Gold & Platinum Co. Sub., 525 Harbor Blvd., Belmont, Calif.
Driver-Harris Co., 201 Middlesex St., Harrison, N.J.
Driv-Lok Sales Corp, 777 Park Ave., Sycamore, Ill.
Duane Specialties, Ltd., 2 Johnson St., Newark 5, N.J.
Du-Co Ceramics Co., Box 278, Saxonburg, Pa.
Ductile Iron Foundry, Inc., Honeyspot Rd. Extension, Stratford, Conn.
Dodek & Bock Spring Mfg. Co., 4014 W Grand Ave., Chicago 51, Ill.
Duffin Mfg. Co., 2307 Leavitt Rd., Lorain, Ohio
Du-Lite Chemical Corp., Middletown, Conn.
Duluth Brass Works Co., 5002 Ramsey St., Duluth 7, Minn.
Dumont Corp. (Ad p 428)
607 Irwin St., San Rafael, Calif.
Dunnican Assoc., 352 Plymouth Rd., Union, N.J.
Duplex Mfg. Corp., P.O. Box 418, Fort Smith, Ark.
Duplican Co., Inc., 1221 Turnpike Rd., Westboro, Mass.
du Pont de Nemours, E. I. & Co., Inc. (Ad pp 231, 315)
Wilmington 98, Del.
Dura Plastics of New York, Inc., 303 5th Ave., New York 16, N.Y.
Durable Formed Products, Inc., 74 Varick St., New York 13, N.Y.
Durable Rubber Products Co., 609 W Lake St., Chicago 6, Ill.
Duralac Chemical Corp., 84 Lister Ave., Newark 5, N.J.
Dura-Lee Corp., 1102 S Mill, Kansas City, Kan.
Duraloy Co. (Ad p 417)
Bridge St., Scottdale, Pa.
Durethene Corp., 1859 S 55th Ave., Chicago 50, Ill.
Duriron Co., Inc., 450 N Findlay St., Dayton, Ohio
Modern Industrial Plastics Div., Box 1019, Dayton 1, Ohio
Duro Screw & Mfg. Co., 1064 Springfield Rd., Union, N.J.
Du-Wel Metal Products, Inc., P.O. Box 307 Bangor Mich
Dyna-Therm Chemical Corp., 3813 Hoke St., Culver City, Calif.
Plas-Kem Corp. Div., 100 W Alameda St., Burbank, Calif.

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Eagle-Picher Co., American Bldg., Cincinnati 1, Ohio
Chicago Vitreous Corp. Div., 1425 S 55th Ct., Cicero 50, Ill.
Fabricon Products Div. (Ad p 275)
1721 W Pleasant Ave., River Rouge 18, Mich.
Earl Paint Corp., 240 Genesee St., Utica 2, N.Y.
Earley, Sam C. Corp., 3230 Monroe St., Toledo 6, Ohio
East Birmingham Bronze Foundry Co., 831 N 36th Way, Birmingham 4, Ala.
Eastern Brass & Copper Co., 1122 E 180th St., New York 60, N.Y.
Eastern Machine Screw Corp., Truman & Barclay Sts., New Haven 6, Conn.
Eastern Malleable Iron Co., P.O. Box 349, Wilmington 99, Del.
Eastern Rolling Mills, Inc., 1122 E 180th St., New York 60, N.Y.
Eastern Smelting & Refining Corp. 109 W Brookline St., Boston 18 Mass.
Eastern Stainless Steel Corp., P.O. Box 1975, Baltimore 3, Md.
Eastern Tool & Mfg. Co., 1 Montgomery St., Belleville 9, N.J.
Eastern Tool & Stamping Co., Inc. 110 Ballard St., Saugus, Mass.
Eastman Kodak Co., 343 State St., Rochester 4, N.Y.
Eastman Chemical Products, Inc. Sub. (Ad p 494)
260 Madison Ave., New York 16, N.Y.
Texas Eastman Co. Div., Longview, Tex.
Easton Plastic Products Co., Inc., 900 Line St., Easton, Pa.
Eaton Mfg. Co., 9711 French Rd., Detroit, Mich.
Foundry Div. (Ad p 459)
700 E Huron, Vassar, Mich.
Powdered Metals Div., 325 Jay St., Coldwater, Mich.
Reliance Div., 25 Charles Ave., Massillon, Ohio
Eberhart Steel Products, Powdered Metals Div., 317 E Jefferson Blvd., Mishawaka, Ind.
Eby, Hugh H. Co., 4701 Germantown Ave., Philadelphia 20, Pa.
Eclipse Plastic Industries, Inc., Box 430, Sarasota, Fla.
Economy Machine Products Co., 5214 W Lawrence Ave., Chicago 30, Ill.
Edgar Plastic Kaolin Co., Materdyne Ave., Edgar, Fla.
Edgcomb Steel & Aluminum Corp., Hillside Ave., N.J.
Edgewater Steel Co., Box 478, Pittsburgh, Pa.
Edna Lite Optical Co., Inc., 200 N Water St., Peekskill, N.Y.
Egan & Hausman Co., Inc., 9-02 43rd Rd., Long Island City 1, N.Y.
Egyptian Lacquer Mfg. Co., P.O. Box 444, Newark 1, N.J.
Ehrsam, J. B. & Sons Mfg. Co., Enterprise, Kan.
Eimco Corp., American Foundry & Machine Div., P.O. Box 300, Salt Lake City 10, Utah
Ekstrand & Tholand, 420 Lexington Ave., New York 17, N.Y.
Elastic Stop Nut Corp. of America, 2330 Vauxhall Rd., Union, N.J.
Elastomer Chemical Corp., 212 Wright St., Newark 7, N.J.
Elchinger, Charles F., 916 Magazine St., New Orleans 12, La.
Elco Tool and Screw Corp., 1800 Broadway, Rockford, Ill.
Electric Autolite Co., Champlain & Mulberry Sts., Toledo 1, Ohio
Ceramic Div., Fostoria, Ohio
Woodstock Div., 501 Clay St., Woodstock, Ill.
Electric Materials Co., Clay & Washington Sts., North East, Pa.
Electric Steel Castings Co., 1045 Main St. Speedway, Indianapolis 24, Ind.
Electric Steel Foundry Co., 2141 NW 25th Ave., Portland 10, Ore.
Electric Storage Battery Co., Stokes Molded Products Div., Taylor St. & Webster, Trenton 4, N.J.
Electrical Refractories Co., East Palestine, Ohio
Electro Chemical Engineering & Mfg. Co., 750 Broad St., Emmaus, Pa.
Electro Refractories & Abrasives Corp., Willett Rd., Lackawanna 18, N.Y.
Electrocast Steel Foundry Co., 4701 W 15th Pl., Cicero 50, Ill.
Electrofilm, Inc., 7116 Laurel Canyon Blvd., North Hollywood, Calif.
Electrolizing Co., 1505 East End Ave., Chicago Heights, Ill.
Electron Corp., 651 Rio Grande Ave., Littleton, Colo.
Electronic Parts Mfg. Co., Inc., 508 25th St., Union City, N.J.
Electronic Production & Development, Inc., Chemical Div., 501 N Prairie Ave., Hawthorne, Calif.
Elgin National Watch Co., 107 National St., Elgin, Ill.
Eljay Corp., 2900 Herbert St., Baltimore 16, Md.
Elk Engineering Works, Inc., 220 Stackpole St., St. Marys, Pa.
Elkhart Foundry & Machine Co., Inc., 220-330 S Elkhart Ave., Elkhart, Ind.
Elkhart Iron Works, 1217-33 Broad St., St. Joseph, Mich.
Elliott Bros. Steel Co., 902-914 N Cedar St., New Castle, Pa.
Ellwood City Iron & Wire Co., 416 Pittsburgh Circle, Ellwood City, Pa.
Elm Coated Fabrics Co., Inc., 261 5th Ave., New York 16, N.Y.
Elsby, J.S. Inc., 3223 W Burnham St., Milwaukee 15, Wis.
Emerson & Cuming, Inc., 869 Washington St., Canton, Mass.
Emerson-Sack-Warner Corp., 85 Washington St., Somerville, Mass.
Emery, George D. Co., 220 11th Ave., New York, N.Y.
Emmaus Foundry & Machine Co., 4th & Furnace Sts., Emmaus, Pa.
Empire Foundry Co., Inc., 429 3rd St., Oakland 7, Calif.
Empire Metal Co., 820 E Water St., Syracuse 3, N.Y.

In contacting suppliers, please mention the Materials Selector Issue

Empire Pattern and Foundry Co., P.O. Box 1647, Tulsa 1, Okla.
Empire Spring Co., 210 S Albe St., Elyria, Ohio
Empire Steel Castings, Inc., P.O. Box 139, Reading, Pa.
Enamel Products Co., 341 Eddy Rd., Cleveland 8, Ohio
Endicott Forging & Mfg. Co., Inc., 1901 North St., Endicott, N.Y.
Enflo Corp., Fellowship Rd. & Rt. #73, Maple Shade, N.J.
Engelhard Industries, Inc., 904 Passaic Ave., East Newark, N.J.

American Platinum & Silver Div. (Ad pp 158-159, 493)
231 New Jersey R.R. Ave., Newark 5, N.J.

Amersil Quartz Div. (Ad pp 158-159)
685 Ramsey Ave., Hillside, N.J.

Baker Platinum Div., 113 Astor St., Newark, N.J.

Makepeace, D.E. Div. (Ad pp 158-159)
Pine & Durham Sts., Attleboro, Mass.

Wilson, H. A. Div., 2655 U.S. Rte. 22, Union, N.J.

Engineered Ceramics Mfg. Co., 1435 W Fulton St., Chicago 7, Ill.
Engineered Plastics, Inc., American Sinterings Div., P.O. Drawer P, Watertown, Conn.
Engineered Precision Casting Co., Highway 79, P.O. Box 68, Matawan, N.J.
Engineering Products & Specialties, Inc., Dunnel Lane, Pawtucket, R.I.
Englander Co., Inc., Industrial Products Div., 227 N. Warwick Ave., Baltimore 23, Md.
Enoch Mfg. Co., P.O. Box 5201, Portland 16, Ore.
Enterprise Galvanizing Co., 2507 E Cumberland St., Philadelphia 25, Pa.
Enterprise Wheel & Car Corp., P.O. Box 151, Bristol, Va.
Enthone, Inc. (Ad p 350)
442 Elm St., New Haven 8, Conn.
Erdle Perforating Co., Inc., 171 York St., Rochester 11, N.Y.
Erie Bolt & Nut Co., 1325 Liberty St., Erie, Pa.
Erie Bronze Co., 19th & Chestnut Sts., Erie, Pa.
Erie Casting Co., 1534 German St., Erie, Pa.
Erie Ceramic Arts Co., 3120 W 22nd St., Erie, Pa.
Erie Enameling Co., 1400 W 20th St., Erie 4, Pa.
Erie Malleable Iron Co., 680 W 12th St., Erie, Pa
Erie Resistor Corp., Plastics Div., 644 W 12th St., Erie, Pa.
Erie Scientific Corp., 693 Seneca St., Buffalo 10, N.Y.
Erskine Precision Wire Corp., 210 S Broad St., Emporium, Pa.
Ervite Corp., 4000 W Ridge Rd., Erie, Pa.
Escambia Chemical Corp., 261 Madison Ave., New York 16, N.Y.
Essential Bar Products Co., 2526 Brooklyn Road, Jackson, Mich.
Essex Wire Corp., 1601 Wall St., Fort Wayne, Ind.
Carolina Industrial Plastics Div., Mount Airy, N.C.
Essex Industrial Products Div., 2601 S Adams, Marion, Ind.
Magnet Wire Div., 1601 Wall St., Fort Wayne, Ind.
Est Co., Inc., Grafton, Wis.
Etched Products Corp., 1100 Brook Ave., New York 56, N.Y.
Ethylene Chemical Corp., 245 Broad St., Summit, N.J.
Eureka Electric Products Co., Clay St., North East, Pa.
Eutectic Welding Alloys Corp., 40-40 172nd St., Flushing 58, N.Y.
Evans, George Corp., 121 37th St., Moline, Ill.
Evans Metal Co., 740 Lambert Dr. NE, Atlanta 5, Ga.
Evans Products Co., Hardboard Div., P.O. Box 651, Corvallis, Ore.
Everard Tap & Die Corp., 215 E 144th St., New York 51, N.Y.
Everlite Corp., 1218 E Cherry St., Seattle 22, Wash.
Exalco Mfg. Co. (Ad p 420)
46 Sheldon Rd., Berea, Ohio
Excelsior Leather Washer Mfg. Co., Inc., 720 Chestnut St., Rockford, Ill.
Exeter Mfg. Co., 1451 Broadway, New York 36, N.Y.
Exmet Corp., 127 Marbledale Rd., Tuckahoe, N.Y.
Extruders, Inc., 3232 W El Segundo Blvd., Hawthorne, Calif.
Eynon-Dakin Co., 9900 Freeland Ave. Detroit 27, Mich.

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Fabristeel Products, Inc., 21500 W 8 Mile Rd., Detroit 41, Mich.
Fahralloy Co., 149th St. & Loomis St., Harvey, Ill.
Fairbanks, Morse & Co., Beloit, Wis.
Fairchild Screw Products, Inc., White St., Winsted, Conn.
Fairfield Aluminum Castings Co., 603 N 8th St., Fairfield, Iowa
Fairmont Aluminum Co. (Ad p 161)
Fairmont, W Va.
Faige Engineering Corp., 4733 Elm St., Bethesda 14, Md.
Falk Corp., Box 492, Milwaukee 1, Wis.
Falls Machine Co., 1625 Massillon Rd., Akron 12, Ohio
Falstrom Co., 70 Falstrom Ct., Passaic, N.J.
Fanner Mfg. Co., Brookside Park, Cleveland 9, Ohio
Munray Products Div., 12400 Crossburn Ave., Cleveland 11, Ohio
Fansteel Metallurgical Corp. (Ad pp 174-175)
North Chicago, Ill.
Farley & Loetscher Mfg. Co., Plastics Div. (Ad p 276)
7th & White, Dubuque, Iowa
Farnam Mfg. Co., 2000 Sweeten Creek Rd., Asheville, N.C.
Farrel-Birmingham Co., Inc., 25 Main St., Ansonia, Conn.
Farrelloy Co., 1243-45 N 26th St., Philadelphia 21, Pa.
Farwell Metal Fabricating, 77 W Fairfield Ave., St. Paul 7, Minn.
Faultless Rubber Co., Ashland, Ohio
Fearon Foundry Co., 1420 W Kinzie St., Chicago 22, Ill.
Federal Die Casting Co., 2226 N Elston, Chicago, Ill.
Federal Machine and Welder Co., 1745 Overland Ave. NE, Warren, Ohio
Federal Malleable Co., 805 S 72nd St., Milwaukee, Wis.
Federal Screw Works, Congdon St., Chelsea, Mich.
Federal Steel Products Corp., 415 N St. Charles St., Houston 3, Tex.
Federal Tool Corp. (Ad p 436)
3600 W Pratt Blvd., Chicago 45, Ill.
Federal Tool Mfg. Co., 3600 Alabama Ave., Minneapolis 16, Minn.
Felt Products Mfg. Co., 7450 N McCormick Blvd., Skokie, Ill.
Felters Co. (Ad p 310)
220 South St., Boston 11, Mass.
Femco Mfg. Co., Inc., 22845 Hoover Rd., Detroit 5, Mich.
Fenestra, Inc., 2250 E Grand Blvd., Detroit 11, Mich.
Ferro Corp., 4150 E 56th St., Cleveland 5, Ohio
Fiber Glass Div. (Ad p 321)
Fiber Glass Rd., Nashville 11, Tenn.
Louthan Mfg. Co. Div. P.O. Box 781, East Liverpool, Ohio
Ferro Enameling Co., 1100 57th Ave., Oakland 21, Calif.
Ferro Powdered Metals, Inc., Box 312, Salem, Ind.
Ferro-Co Corp., Schori Process Div., 8-11 43rd Rd., Long Island City 1, N.Y.
Ferroxcube Corp. of America, E Bridge St., Saugerties, N.Y.
Fiber Glass Industries, Inc., Amsterdam, N.Y.
Fiberfil, Inc., Fox Farm Road, Warsaw, Ind.
Fiberglass Ohio Inc., 9603 Clinton Rd., Cleveland 9, Ohio
Fiberite Corp. (Ad p 281)
516 W 4th, Winona, Minn.
Fibron Products, Inc., 500 Fibron Bldg., 45 Mechanic St., Buffalo 2, N.Y.
Fidelity Chemical Products Corp., 470 Frelinghuysen Ave., Newark 12, N.J.
Fidelity Felt & Mfg. Co., 22 W 15th St., New York 11, N.Y.
Figley Die & Stamping Co., 401 Agnes St., Defiance, Ohio
Filon Plastics Corp., 333 N Van Ness Ave., Hawthorne, Calif.
Filpaco Industries, Inc., 2426 S Michigan Ave., Chicago 16, Ill.
Fine Organics, Inc., 209-211 E 19th St., New York, N.Y.
Finkl, A. & Sons Co., 2011 Southport Ave., Chicago 14, Ill.
Firestone Plastics Co., P.O. Box 690, Pottstown, Pa.
Firestone Tire & Rubber Co., 1200 Firestone Pkwy., Akron 17, Ohio
Firestone Rubber & Latex Products Co., Div., 1 Firestone Ave., Fall River, Mass.
World Bestos Div., 1112 S 25th St., New Castle, Ind.
Firmaline Products of Crompton & Knowles (Ad p 457)
7 Pierce Ave., Midland Park, N.J.
Firth Sterling, Inc., 3113 Forbes Ave., Pittsburgh, Pa.
Fischer Casting Co., Inc., P.O. Box M, Dunellen, N.J.
Fischer & Porter Co., 510 Jacksonville Rd., Warminster, Pa.
Warminster Fiberglass Co. Div., County Line & Warminster Rd., Warminster, Pa.
Fischer Special Mfg. Co., 450 Morgan St., Cincinnati 20, Ohio
Fish-Schurman Corp., 70 Portman Rd., New Rochelle, N.Y.
Fitchburg Foundry, Inc., Benson St., Fitchburg, Mass.
Fitzgibbons Boiler Co., Inc., Oswego, N.Y.
FitzSimons Mfg. Co., 3775 E Outer Drive, Detroit 34, Mich.
Fletcher Enamel Co., P.O. Box 67, Dunbar, W. Va.
Flexfirm Products, 2300 N Chico Ave., El Monte, Calif.
Flexible Tubing Corp., Guilford, Conn.
Flexonics Corp., 1315 S 3rd Ave., Maywood, Ill.
Flexrock Co., 36th & Filbert Sts., Philadelphia 1, Pa.
Fluoro-Plastics Inc. Div., 36th & Filbert Sts., Philadelphia 1, Pa.
Flood City Brass & Electric Co., Messenger & Elder Sts., Johnstown, Pa.
Florence Pipe Foundry & Machine Co., Front St., Florence, N.J.
Florin Foundry & Mfg. Co., Florin, Pa.
Fluorocarbon Co., 1754 S Clementine St., Anaheim, Calif.
Flynn & Emrich Co., 301 Holliday St., Baltimore 2, Md.
Flynn, Michael Mfg. Co., 700 E Godfrey Ave., Philadelphia 24, Pa.
Foam Products, Inc., P.O. Box 27, Manchester, Pa.
Foamade Industries, 14851 W 11 Mile Rd., Oak Park 37, Mich.
Foamalum Corp., 508 Water St., Peru, Ill.
Follansbee Steel Corp., Sheet Metal Specialty Div., P.O. Box 567, Follansbee, W. Va.
Food Machinery & Chemical Corp., 161 E 42nd St., New York 17, N.Y.
Chemicals & Plastics Div., 161 E 42nd St., New York 17, N.Y.
F M C Organic Chemicals Div., 161 E 42nd St., New York 17, N.Y.
Sonith Foundries Div., 50 Shelby St., Indianapolis 6, Ind.
Foote Mineral Co., 18 W Chelten Ave., Philadelphia 44, Pa.
Fordsell Machine Products Co., 4433 E 8 Mile Rd., Warren, Mich.
Forest City Foundries Co., 2500 W 27th St., Cleveland 13, Ohio
Forg, Peter Mfg. Co., Park St., Somerville 43, Mass.
Formed Tubes, Inc., Prairie & Albert Sts., Sturgis, Mich.
Fort Howard Steel & Wire Co., 200 9th St., Green Bay, Wis.
Fort Worth Steel & Machinery Co., 3504 Jackson St., Fort Worth, Tex.
Foss Mfg. Co., P.O. Box 553, Twin Falls, Id.
Foster Aluminum Alloy Products Corp., Pearl St., Forestville, N.Y.
Foster Grant Co., 289 N Main St., Leominster, Mass.
Foster Wheeler Corp., 165 Broadway, New York, N.Y.
Fox Co., 3400 Beekman St., Cincinnati, Ohio
Fox Edge Co., Inc., 1995 Middlesex St., Lowell, Mass.
Fox Products Co., 4720 N 18th St., Philadelphia 41, Pa.
France, J. H. Refractories Co., 710 France Rd., Snow Shoe, Pa.
Franklin Cotton Mill Co., 1108 Central Pkwy., Cincinnati 10, Ohio
Franklin Glue Co., 119 Chestnut St., Columbus 15, Ohio
Franklin Mineral Products Co., P.O. Box 28, Franklin, N.C.
Franklin Plastics, Inc., 315 Grant St., Franklin, Pa.
Frasse, Peter A. & Co., Inc. (Ad p 179)
17 Grand St., New York 13, N.Y.
Frederick Iron & Steel, Inc., 7th & East Sts., Frederick, Md.
Fremont Casting Co., 105 Fremont St., Worcester, Mass.
Frenchtown Porcelain Co., Frenchtown, N.J.
Friedrich & Dimmock, Inc., Lincoln Ave., Millville, N.J.
Frisby, R. J. Mfg. Co., 246 N Western Ave., Chicago 12, Ill.
Fromson Orban Co., Inc., 261 Madison Ave., New York, N.Y.
Frontier Bronze Corp. (Ad p 178)
4870 Packard Road, Niagara Falls, N.Y.
Frost Paint & Oil Corp., 1203 NE Tyler, Minneapolis, Minn.
Frost Rubber Co., 1407 N Dayton St., Chicago 22, Ill.
Fry Plastics International, 8601 S Figueroa, Los Angeles 3, Calif.
Fryling Mfg. Co., 531 W 11th St., Erie, Pa.
Fuller, H. B. Co., 255 Eagle, St. Paul 2, Minn.
Fuller, W. P. & Co., 301 Mission St., San Francisco, Calif.
Fullerton Mfg. Co., 343 E Santa Fe Ave., Fullerton, Calif.
Fulton Foundry & Machine Co., Inc., Cleveland, Ohio

Addresses of Suppliers

Fulton Gold Refiners Corp., 71 Fulton St., New York 38, N.Y.
Furane Plastics, Inc., 4516 Brazil St., Los Angeles 39, Calif.

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G. & C. Foundry Co., W Monroe & Olds St., Sandusky, Ohio
G & G Mfg. Co., 3223 W Fillmore St., Chicago 24, Ill.
G & Z Automatic Products Co., 2434 Brooklyn Rd., Jackson, Mich.
Gale Mfg. Co., 115 N Albion St., Albion, Mich.
Gallgher Co., 545 W 8th St., P.O. Box 209, Salt Lake City 10, Utah
Gamble Bros., Inc., Special Products Div., 4601 Allmond Ave., Louisville 9, Ky.
Gantner Screw Products Co., Inc., 20 S Walnut St., Springfield, Ohio
Gar Precision Parts, Inc., 190 Henry St., Stamford, Conn.
Garco Mfg. Co., Inc., 744 N Ada St., Chicago 22, Ill.
Garden State Forge Co., 1501 Jersey St., South Plainfield, N.J.
Garfield Mfg. Co., 10 Midland Ave., Wallington, N.J.
Garlock Packing Co., 402 Main St., Palmyra, N.Y.
U.S. Gasket Plastics Div., 600 N 10th St., Camden 1, N.J.
Gartland Foundry Co., 4th & Grant Sts., Terre Haute, Ind.
Gartland-Haswell Foundry, Inc., 430 W Park St., Sidney, Ohio
Gary Lynn Co., 926 York St., Cincinnati 14, Ohio
Gary Steel Products Corp., P.O. Box 449, Lynchburg, Va.
Gates Engineering Co., 100 S West St., Wilmington 99, Del.
Gates Rubber Co., 999 S Broadway, Denver, Colo.
Gatke Corp., Engineering Div., 228 N LaSalle St., Chicago 1, Ill.
Geauga Industries Co., Middlefield, Ohio
General Alloys Co., 405 W 1st St., South Boston, Mass.
General Aluminum Mfg. Co., 3027 E 55th St., Cleveland 27, Ohio
General American Transportation Corp., 135 S LaSalle St., Chicago 3, Ill.
Kanigen Div. (Ad p 355)
135 S LaSalle St., Chicago 3, Ill.
Parker-Kalon Div., 1 Peekay Dr., Clifton, N.J.
Plastics Div. (Ad p 411)
135 S LaSalle St., Chicago 3, Ill.
Plate & Welding Div., 135 S LaSalle St., Chicago 3, Ill.
General Aniline & Film Corp., Antara Chemicals Div., 435 Hudson St., New York 14, N.Y.
General Asbestos Gasket Mfg. Corp., 1721 S 7th St., St. Louis 4, Mo.
General Cable Corp., 420 Lexington Ave., New York 17, N.Y.
General Chain & Mfg. Corp., 3182 Beekman St., Cincinnati 23, Ohio
General Drop Forge Corp., 1738 Elmwood Ave., Buffalo, N.Y.
General Dynamics Corp., Liquid Carbonic Div., 135 S LaSalle St., Chicago 3, Ill.
General Electric Co., 1 River Rd., Schenectady 5, N.Y.
Chemical Materials Dept., 1 Plastics Ave., Pittsfield, Mass.
Chemical & Metallurgical Div., 2200 N 22nd St., Decatur, Ill.
Foundry Dept., 1 River Rd., (Bldg. 96), Schenectady, N.Y.
Insulating Materials Dept., 23 River Rd., Schenectady 5, N.Y.
Laminated Products Dept., Coshocton, Ohio
Lamp Wire & Phosphors Dept., 21800 Tungsten Rd., Cleveland 17, Ohio
Metallurgical Products Dept., P.O. Box 237, Roosevelt Park Annex, Detroit 32, Mich.
Plastics Dept., N 22nd St., Decatur, Ill.
Silicone Products Dept., Waterford, N.Y.
General Engineering Works, 4701 W Division St., Chicago 51, Ill.
General Extrusions, Inc. (Ad p 462)
4040 Lake Park Rd., Youngstown 12, Ohio
General Findings & Supply Co., Industrial Div., School & Pearl Sts., Attleboro, Mass.
General Foundry & Mfg. Co., Flint, Mich.
General Gasket, Inc., Middletown, Conn.
General Industries Co., Molded Plastic Div., Taylor & Olive Sts., Elyria, Ohio
General Iron Works Co., P.O. Box 2490, Denver 1, Colo.
General Malleable Corp., 706 E Main St., Waukesha, Wis.
General Metals Corp., 550 85th Ave., Oakland, Calif.
General Metals Powder Co., 130 Elinor Ave., Akron 5, Ohio
General Mills, Inc., Chemical Div., S Kensington Rd., Kankakee, Ill.
General Motors Corp., General Motors Bldg., Detroit, Mich.
Brown Lipe Chapin Div., GM Circle, Town Line Rd., Syracuse 1, N.Y.
Central Foundry Div., 37 Florence St., Saginaw, Mich.
Fabricast Div., 3rd & Monon, Bedford, Ind.
Moraine Products Div., 1420 Wisconsin Blvd, Dayton 1, Ohio
Rochester Products Div. (Ad p 435)
1000 Lexington Ave., Rochester 3, N.Y.
General Plastics Corp., 1400 N Washington St., Marion, Ind.
General Plastics Corp., 165 3rd Ave., Paterson, N.J.
General Plastics Mfg. Co., 3481 S 35th St., Tacoma 9, Wash.
General Powdered Metal Products, Inc., Holly Corp., 523 West Ave., Norwalk, Conn.
General Refractories Co., 1520 Locust St., Philadelphia 2, Pa.
General Screw Products Corp., 1190 Brooks Ave., Rochester 19, N.Y.
General Sintering Corp., 1830 N 32 Ave., Melrose Park, Ill.
General Smelting Co., 2901 E Westmoreland St., Philadelphia, Pa.
General Steel Castings Corp., 1417 State St., Granite City, Ill.
General Tire & Rubber Co., 1700 Factory Ave., Marion, Ind.
Bolta Products Div., 70 Garden St., Lawrence, Mass.
Chemical Div., 1485 Archwood, Akron 9, Ohio
Industrial Products Div., Wabash, Ind.
Marion Div., Marion, Ind.
Respro Div., 530 Wellington Ave., Cranston 10, R.I.
Textileather Div., 607 Madison Ave., Toledo 8, Ohio
General Veneer Mfg. Co., 8652 Otis, South Gate, Calif.
Genesee Laboratory, Inc., 16 Garden St., Auburn, N.Y.
Geometric Stamping Co., 1111 E 200th St., Cleveland 17, Ohio
George, P. D. Co., 5100 N 2nd St., St. Louis, Mo.
Georgia Iron Works, Augusta, Ga.
Georgia-Pacific Corp., Equitable Bldg., Portland, Ore.
Gerstenslager Co., E Bowman St., Wooster, Ohio
Geuder, Paeschke & Frey Co., 324 N 15th St., Milwaukee 1, Wis.
Giant Grip Mfg. Co., 113 Osceola St., Oshkosh, Wis.
Gibb Walton Leather Co., 54th & Grays Ferry Ave., Philadelphia 43, Pa.
Gibson Electric Co. (Ad p 466)
Box 545, Delmont, Pa.
Gibson & Kirk Co., Warner & Bayard St., Baltimore 30, Md.
Gilbert & Bennett Mfg. Co., Georgetown, Conn.
Gilbert Brass Foundry Co., 5036 Farlin Ave., St. Louis 15, Mo.
Gillett & Eaton, Inc., 847 Doughty, Lake City, Minn.
Gilman Bros. Co., Gilman, Conn.
Gisholt Machine Co., Masterglas Div., 1245 E Washington Ave., Madison 10, Wis.
Gladding, McBean & Co., Technical Ceramic Div., 1551 S Primrose Ave., Monrovia, Calif.
Glamorgan Pipe and Foundry Co., P.O. Drawer 740, Lynchburg, Va.
Glasby, J. P. Mfg. Co., Inc., 1 Montgomery St., Belleville 9, N.J.
Glaskyd, Inc., Eckel Rd., Perrysburg, Ohio
Glass Laboratories, 863 65th St., Brooklyn 20, N.Y.
Glass Reinforced Plastics Corp., 405 W Sophia, Maumee, Ohio
Glastic Corp. (Ad p 256)
4321 Glenridge Rd., Cleveland 21, Ohio
Gleason Corp., Anthes Div., 20th St. & Ave. M, Fort Madison, Iowa
Glenn, Joseph & Sons, Inc., Clifton Hts., Pa.
Glidden Co., 1717 Summer St., Hammond, Ind.
Chemical Divs., Metals Dept. (Ad p 429)
1717 Summer St., Hammond, Ind.
Industrial Paint Div. (Ad p 248)
900 Union Commerce Bldg., Cleveland 14, Ohio
Globe Imperial Corp., Plastic-Seal Div., 2038 Kishwaukee, Rockford, Ill.
Globe Industries, Inc., Supermet Div. (Ad p 464)
1466 Cincinnati St., Dayton 8, Ohio
Globe Paint Works, Inc., P.O. Box 36, Williamsport, Pa.
Globe Steel Abrasive Co., 238 1st Ave., Mansfield, Ohio
Globe Union, Inc., Centralab Div. (Ad p 449)
946 E Keefe Ave., Milwaukee 1, Wis.
Glo-Brite Products, Inc., 6415 N California Ave., Chicago 45, Ill.
Glover Machine Works, Butler St., Marietta, Ga.
Gluntz Brass & Aluminum Foundry Co., 10815 Harvard Ave., Cleveland 5, Ohio
Gold Leaf & Metallic Powders, Inc., 145 Nassau St., New York, N.Y.
Gomar Mfg. Co., Inc., 1501 W Blancke St., Linden, N.J.
Goodrich, B.F. Chemical Co., 3135 Euclid Ave., Cleveland 15, Ohio
Hood Rubber Co. Div., 99 Nichols Ave., Watertown, Mass.
Sponge Products Div., Shelton, Conn.
Goodrich, B.F. Industrial Products Co., 500 S Main St., Akron, Ohio
Goodrich-Gulf Chemicals, Inc., 1717 E 9th St., Cleveland 14, Ohio
Goodyear Tire & Rubber Co., 1144 E Market St., Akron 16, Ohio
Chemical Div., 1144 E Market St., Akron 16, Ohio
Gordon Chemicals, Inc., 500 A St., Wilmington 99, Del.
Goshen Rubber Co., Inc. (Ad p 438)
1525 S 19th St., Goshen, Ind.
Goslin Birmingham Mfg. Co., Inc., 3521 10th Ave. N, Birmingham 1, Ala.
Gossett and Hill Co., 7185 W Bloomingdale, Chicago 35, Ill.
Gotham Plastics Corp., 220 E 134 St., New York 51, N.Y.
Gowanda Furnaces, Inc., 7 Palmer St., Gowanda, N.Y.
Grace, W.R. & Co., 7 Hanover Sq., New York, N.Y.
Davison Chemical Co. Div., Baltimore 3, Md.
Dewey & Almy Chemical Co. Div., 62 Wittemore Ave., Cambridge 40, Mass.
Polymer Chemicals Div., 225 Allwood Rd., Clifton, N.J.
Grafton Foundry Co., 1003 Bridge St., Grafton, Wis.
Graham, James Co., 293 Wooster St., New Haven Conn.
Gra-Iron Foundry Corp., 501 S 12th Ave., Marshalltown, Iowa
Grammes, L.F. & Sons, Inc., 380 Union St., Allentown, Pa.
Grand Haven Stamped Products Co., Griffen & Madison Sts., Grand Haven, Mich.
Grand Rapids Brass Co., 420 50th St., SW, Grand Rapids 8, Mich.
Grand Rapids Varnish Corp., 1350 Steele St., SW, Grand Rapids, Mich.
Grand Sheet Metal Products Co., Consumer Products Div., 2055 Ruby St., Melrose Park, Ill.
Granite City Steel Co., 20th & Madison Aves., Granite City, Ill.
Graphite Metallizing Corp., 1058 Nepperhan Ave., Yonkers 3, N.Y.
Graphite Products Corp., Trumbull County, Brookfield, Ohio
Graphite Specialties Corp. (Ad p 309)
64th St. & Pine Ave., Niagara Falls, N.Y.
Grass, M.J. Machine Products Co., 19 Northampton St., Buffalo 9, N.Y.
Graton & Knight Co., 356 Franklin St., Worcester, Mass.
Gray-Syracuse, Inc., W Seneca St., Manlius, N.Y.
Great American Industries, Inc., Rubatex Div., Bedford, Va.
Great Lakes Carbon Corp., 18 E 48th St., New York 17, N.Y.
Grede Foundries, Inc., 1320 S 1st St., Milwaukee 1, Wis.
Green Bay Foundry & Machine Works, 401 S Broadway, Green Bay, Wis.
Green, A.P. Fire Brick Co., Mexico, Mo.
Green River Steel Corp., P.O. Drawer 637, Owensboro, Ky.
Greenback Industries, Inc., 2527 W Maple Rd., Birmingham, Mich.
Greene, G.G. Corp., Box 900, Warren, Pa.
Greene Mfg. Co., 1028 Douglas Ave., Racine, Wis.
Greene, Tweed & Co., North Wales, Pa.
Greenlee Foundry Co., 4600 W 14th St., Chicago 50, Ill.
Green-Walker Galvanizing Co., Inc., 5002 Jefferson Highway, New Orleans 21, La.
Greer Stop Nut Co., 2620 W Flournoy St., Chicago 12, Ill.

In contacting suppliers, please mention the Materials Selector Issue

Gregg Metal Products Inc., 1333 N 9th St., Milwaukee 5, Wis.
Gregory Industries Inc., Nelson Stud Welding Div., 28th St. & Toledo Ave., Lorain, Ohio
Gregory Thomas Galvan Works, 4900 Grand Ave., Maspeth 78, N.Y.
Grems Mfg. Co., 5635 S 6th St., Klamath Falls, Ore.
Grey, C.M. Industries, Inc., 358 Central Ave., East Orange, N.J.
Gries Reproducer Corp., 153 Beechwood Ave., New Rochelle, N.Y.
Grigoleit Co., 740 E North, Decatur, Ill.
Grimes Mfg. Co., Plastic Research Products, 200 Beech St., Urbana, Ohio
Grimm Foundry Co., Inc., Chimney Rock Rd., Bound Brook, N.J.
Grip Nut Co. (Ad p 498)
Broad & Maple Sts., South Whitley, Ind.
Groov-Pin Corp., 1125 Hendricks Causeway, Ridgefield, N.J.
Gross, Willard N., Inc., 224 Highland Ave., Westmont, Collingswood, N.J.
Guarantee Specialty Mfg. Co., 9651 Carr Ave., Cleveland 8, Ohio
Guilfoy Cornice Works, 1234 Howard St., San Francisco 3, Calif.
Gulton Industries, Inc., 212 Durham Ave., Metuchen, N.J.
Gunite Foundries Corp., 302 Peoples Ave., Rockford, Ill.
Gustin-Bacon Mfg. Co., 210 W 10th St., Kansas City 5, Mo.

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H & H Foundry Machine Co., P.O. Box 238, Jeanette, Pa.
H & H Screw Products, Inc., 570 Elk St., Buffalo 10, N.Y.
H. & H. Screw Products Mfg. Co., 1883 Mineral Spring Ave., North Providence 11, R.I.
H & H Tube & Mfg. Co., 263 N Forman, Detroit 17, Mich.
H & K Machine Service Co., Inc., 6229 Bartmer Ave., St. Louis, Mo.
H. K. Metal Craft Mfg. Corp., 3775 10th Ave., New York, N.Y.
H-P Products, Inc., 510 W Broad St., Louisville, Ohio
H & R Industries, 344 E Walnut St., Nazareth, Pa.
HPL Mfg. Co. 15210 Miles Ave., Cleveland 28, Ohio
Haber, 864 W North Ave., Chicago 22, Ill.
Hack, J.H. Mfg. Co., 7049 Lyndon Ave., Detroit 21, Mich.
Hadley Bros.-Uhl Co., 514 Calvary Ave., St. Louis 15, Mo.
Haffner Bros. Co., Hopple St. Central Pkwy., Cincinnati 25, Ohio
Hagstoz, T.B. & Son, 709 Sansom, Philadelphia 6, Pa
Haigh Mfg. Co., 225 E Grand River, Brighton, Mich.
Halex Corp., 26302 W 7 Mile Rd., Detroit 40, Mich.
Hall C.P. Co., 414 S Broadway, Akron 8, Ohio
Hall Mfg. Co., 175 Linden St., Hackensack, N.J.
Haller, Inc., 16580 Northville Rd., Northville, Mich.
Hallstead Foundry, Inc., Main St., Hallstead, Pa.
Halogen Insulator & Seal Corp., 9960 Pacific Ave., Franklin Park, Ill.
Hamilton Die Cast, Inc., 240 N B St., Hamilton, Ohio
Hamilton Foundry & Machine Co., 1551 Lincoln Ave., Hamilton, Ohio
Hamilton Watch Co., Precision Metals Div., Lancaster, Pa.
Hampden Brass & Aluminum Co., 262 Liberty St., Springfield, Mass.
Hampton Mfg. Co., 111 Cedar St., New Rochelle, N.Y.
Handy & Harman (Ad pp 152, 495)
82 Fulton St., New York 38, N.Y.
Hanford Foundry Co., 119 S Arrowhead Ave., San Bernardino, Calif.
Hauser Products, Inc., 4034 N Kolmar Ave., Chicago 41, Ill.
Hanlon-Gregory Galvanizing Co., 5515 Butler St., Pittsburgh 1, Pa.
Hanovia Chemical Mfg. Co., 1 Central Ave., East Newark, N.J.
Hansell-Elcock, 485 W 23rd Pl., Chicago 16, Ill.
Harbot Die Casting Corp., 52 E Centre St., Nutley, N.J.
Harcast Co., Inc., 620 E Glenolden Ave., Glenolden, Pa.
Hardinge Mfg. Co., 240 Arch St., York, Pa.
Hardman, H. V. Co., Inc., 577 Cortlandt St., Belleville 9, N.J.
Hardy, Charles, Inc., 420 Lexington Ave., New York 17, N.Y.
Hardy Mfg. Corp., W Pearl St., Union City, Ind.
Harnischfeger Corp., 4400 W National Ave., Milwaukee 46, Wis.
Harper, H.M. Co., 8200 Lehigh Ave., Morton Grove, Ill.
Harrington & King Perforating Co., Inc. (Ad p 440)
5671½ Fillmore St., Chicago 44, Ill.
Harris, Benjamin & Co., 11th & State Sts., Chicago Hts., Ill.
Harrisburg Steel Co., 110 E 42nd St., New York 17, N.Y.
Harsco Corp., 3200 Guardian Bldg., Detroit 26, Mich.
Ainsworth-Precision Castings Co. Div., 3200 Guardian Bldg., Detroit 26, Mich
Taylor-Wharton Co., High Bridge, N.J.
Harshaw Chemical Co., 1945 E 97th St., Cleveland 6, Ohio
Hartford Electric Steel Corp., 540 Flatbush Ave., Hartford 10, Conn.
Hartglas Co., 1302 Expressway Dr., Toledo 8, Ohio
Hartwell, H.N. & Son, Inc., Park Square Bldg., 31 St. James St., Boston 16, Mass.
Harvey Aluminum, 19200 S Western Ave., Torrance, Calif.
Harvill Corp., 6251 W Century Blvd., Los Angeles 45, Calif.
Harvin & Co., Box 83, Federal St., Kenilworth, N.J.
Harwood Screw Products, Inc., 1620 E Pleasant St., Springfield, Ohio
Haskelite Mfg. Corp., 701 Ann St., NW, Grand Rapids, Mich.
Hassall, John Inc., P.O. Box 2277, Westbury, N.Y.
Hastings & Co., Inc., 2314 Market St., Philadelphia 3, Pa.
Hauger-Beegle Asso., Inc., 900 W 49th Pl., Chicago 9, Ill.
Hauser Products, Inc., 4034 N Kolmar Ave., Chicago 41, Ill.
Haveg Industries, Inc. (Ad pp 425-426)
900 Greenbank Rd., Wilmington 8, Del.
Taunton Div., 336 Weir St., Taunton, Mass.
Hawkeye Rubber Mfg. Co., 915 Shaver Road NE, Cedar Rapids, Iowa
Hawkridge Bros. Co., 303 Congress St., Boston 10, Mass.
Hawley Products Co., 333 N 6th St., St. Charles, Ill.
Haws Refractories Co., 407 Main St., Johnstown, Pa.
Hay, James E. Co., Inc., 244 Smith St., Lowell, Mass.
Hayden Mica Co., Inc., Main St., Wilmington, Mass.
Hayden Wire Works, Inc., P.O. Box 146, West Springfield, Mass.
Haydon Corp., 3815 9th Ave., New York 34, N.Y.
Hayes Adhesive Co., Inc., Union Blvd. at Brown Ave., St. Louis 15, Mo.
Hayman, Michael & Co., 856 E Ferry St., Buffalo 11, N.Y.
Hays Mfg. Co., 80 W 12th St., Erie, Pa.
Haywilk Galvanizing Inc., P.O. Box 372, Harvey, La.
Hazledine, E.T. Co., 231 S 1st St., Terre Haute, Ind.
Headford Bros. & Hitchins Foundry Co., 1502 Westfield Ave., Waterloo, Iowa
Headly Mfg. Co., 4376 W Ogden Ave., Chicago 23, Ill.
Heatbath Corp., P.O. Box 78, Springfield 1, Mass.
Heavy Minerals Co., 4000 N Hawthorne St., Chattanooga, Tenn.
Heil Process Equipment Corp., 12901 Elmwood Ave., Cleveland 11, Ohio
Heintz Mfg. Co., Front St. & Olney Ave., Philadelphia 20, Pa.
Held, O.P. Inc., 761 Nepperhan Ave., Yonkers 3, N.Y.
Heli-Coil Corp., Shelter Rock Lane, Danbury, Conn.
Heller, A.B. Screw Products, Inc., 14571 Lesure Ave., Detroit 27, Mich.
Heller Tool Co., Heller Dr., Newcomerstown, Ohio
Helmick Foundry-Machine Co., P.O. Box 71, Fairmont, W. Va.
Hendrick Mfg. Co., 50 Dundaff St., Carbondale, Pa.
Henefelt Precision Products, 1630 Herald Ave., Cincinnati 12, Ohio
Henrite Products Corp., Ironton, Ohio
Heppenstall Co., 4620 Hatfield St., Pittsburgh 1, Pa.
Hercules Fastener Co., 2722 N Clybourn St., Chicago 14, Ill.
Hercules Powder Co., Inc., Delaware Trust Bldg., Wilmington 99, Del.
Heresite & Chemical Co., Manitowoc, Wis.
Herker Screw Products, Inc., 4924 N 125th St., Butler, Wis.
Herman Machine & Tool Co., Tallmadge, Ohio
Hersey Metal Products, Inc., Derby, Conn.
Hettleman, K. & Sons, Inc., 9th & Patapsco Aves., Baltimore 25, Md.
Hewitt, John Foundry Co., 15-29 Sherman Ave., East Newark, N.J.
Hewitt-Robins, Inc., 666 Glenbrook Rd., Stamford, Conn.
Hexcel Products, Inc., 2332 4th St., Berkeley, Calif.
Heyden Newport Chemical Corp., American Plastics Corp. Div., 342 Madison Ave., New York 17, N.Y.
Heypian Mfg. Co., E Michigan Ave., Kenilworth, N.J.
Hibben & Co., 9376 S Ewing Ave., Chicago, Ill.
Hica, Inc., 1431 W 59th St., Shreveport, La.
Hicks Corp., Hyde Park Ave., Boston, Mass.
Higbie Mfg. Co., Avon Tube Div., Klein Rd., Rochester, Mich.
High Vacuum Equipment Corp., 2 Churchill Rd., Hingham, Mass.
Hi-Grade Alloy Corp., 3034 E 95th St., Chicago 17, Ill.
Hilfinger Corp., 1800 Westwood Ave., Toledo 7, Ohio
Hiller Aircraft Corp., Adhesive Engineering Div., 1411 Industrial Rd., San Carlos, Calif.
Hills-McCanna Co., 3025 N Western Ave., Chicago 18, Ill.
Hilo Varnish Corp., Industrial Finishes Div., 376 3rd St., Everett 49, Mass.
Himmel Bros. Co., 1409 Dixwell Ave., Hamden, Conn.
Hi-Shear Rivet Tool Co., 2600 W 247th St., Torrance, Calif.
Hitchiner Mfg. Co., Inc., P.O. Box 350, Milford, N.H.
Hitemp Wires, Inc., 1200 Shames Dr., Westbury, N.Y.
Hobart Bros. Co., 1221 Hobart Rd., Troy, Ohio
Hobbs, Clinton E. Co., 203 Chelsea St., Everett 49, Mass.
Hodges, William & Co., Inc., 1627 N American St., Philadelphia 2, Pa.
Hodgman Rubber Co., Tripp St., Framingham, Mass.
Hodgson Foundry Co., 2012 W 13th St., Chicago 8, Ill.
Hoeganaes Sponge Iron Corp. (Ad p 462)
Riverton, N.J.
Hoffman Bronze & Aluminum Casting Co., 1000 Addison Rd., Cleveland 3, Ohio
Hofford Varnish Co., Inc., Broad & 14th Sts., Carlstadt, N.J.
Hohwieler Rubber Co., Inc., 32 W Bridge St., Morrisville, Pa.
Hollingsworth & Vose Co., Washington St., East Walpole, Mass.
Holo-Krome Screw Corp., P.O. Box 98, Elmwood Branch, Hartford 10, Conn.
Holt Products Co., Walnut St., Holt, Mich.
Home Rubber Co., 30 Woolverton Ave., Trenton, N.J.
Homestead Valve Mfg. Co., P.O. Box 348 Coraopolis, Pa.
Hommel, O. Co., P.O. Box 475, Pittsburgh 30, Pa.
Hoofer Mfg. Co., 544 W Lake St., Chicago 6, Ill.
Hooker Chemical Corp., 51 47th St., Niagara Falls, N.Y.
Durez Plastics Div. (Ad pp 232-233)
1967 Walck Rd., North Tonawanda, N.Y.
Hoover Co., Die Casting Div., 101 E Maple St., North Canton, Ohio
Horton-Angell Co., 31 Bicknell St., Attleboro, Mass.
Hoskins Mfg. Co. (Ad p 177)
4445 Lawton Ave., Detroit 8, Mich.
Houdaille Industries, Inc., Fairmount Tool & Forging, Inc. Sub., 10611 Quincy Ave., Cleveland 6, Ohio
Houghton, E.F. & Co., 303 W Lehigh Ave., Philadelphia 33, Pa.
Houston Blow Pipe & Sheet Metal Works, P.O. Box 1692, Houston 1, Tex.
Howard Foundry Co., 1700 N Kostner Ave., Chicago 29, Ill.
Howe Sound Co., 500 5th Ave., New York, N.Y.
Austenal Co. Div., 224 E 39th St., New York, N.Y.
Peerless Roll Leaf Co. Div., 4511 New York Ave., Union City, N.J.
Hoyt, Charles D. Co., Inc., 1118 Forest Ave., Mishawaka, Ind.
Huck Mfg. Co., 2480 Bellevue Ave., Detroit 7, Mich.
Hudsar, Inc., 567 Wilson Ave., Newark 5, N.J.
Hudson Cush-N-Foam Corp., 309 River Rd., Edgewater, N.J.
Hudson Screw Machine Products Co., 4500 W Augusta Blvd., Chicago 51, Ill.
Hudson Wire Co., Pequot Wire Cloth Co. Div., 35 Hoyt St., Norwalk, Conn.
Hughes Glue Co., 3500 St. Aubin Ave., Detroit 7, Mich.
Hughes Tool Co., 5425 Polk Ave., P.O. Box 2539, Houston 1, Tex.
Hull, R.O. & Co., Inc., 1300 Parsons Ct., Rocky River 16, Ohio

Addresses of Suppliers

Humble Oil & Refining Co., Enjay Chemical Co. Div. (Ad pp 266-267)
15 W 51st St., New York 19, N.Y.
Humphrey Castings, Inc., 3944 Riley St., San Diego 10, Calif.
Hungerford Plastics Corp., P.O. Box 376, Morristown, N.J.
Hunt Screw & Mfg. Co., 4117 N Kilpatric Ave., Chicago 41, Ill.
Hunter Engineering Co., 1495 Columbia Ave., Riverside, Calif.
Hunt-Spiller Mfg. Corp., 383 Dorchester Ave., Boston 82, Mass.
Huron Automatic Screw Co., P.O. Box 66, Port Huron, Mich.
Huron Forge & Machine Co., 9041 Alpine Ave., Detroit 4, Mich.
Hyde, A.L. Co., Main St., Grenloch, N.J.
Hydrawlik Co., 131-137 E 1st St., Roselle, N.J.
Hydroforming Co. of America, 7400 W Lawrence Ave., Chicago 31, Ill.
Hydrometals, Inc., Illinois Zinc Co. Div., 2959 W 47th St., Chicago 32, Ill.
Hy-Level Screw Products Co., 2615 Scranton Rd., Cleveland 13, Ohio
Hysol Corp., Olean, N.Y.

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I-F Mfg. Co., New Philadelphia, Ohio
Ideal Can Co., 68 Vine St., Everett 49, Mass.
Ideal Metal Products Co., 4842 W Kinzie St., Chicago 44, Ill.
Illinois Forge, Inc., Rock Falls, Ill.
Illinois Iron & Bolt Co., Carpentersville, Ill.
Illinois Precise Casting Co., 903 N Spaulding Ave., Chicago 51, Ill.
Illinois Smelting & Refining Co., 3637 S Albany Ave., Chicago 32, Ill.
Illinois Tool Works, 2511 N Keeler Ave., Chicago, Ill.
Fastex Div., 195 Algonquin Rd., Des Plaines, Ill.
Shakeproof Div., St. Charles Rd., Elgin, Ill.
Imco Container Corp., 75th & Cleveland Sts., Kansas City, Mo.
Impact Extrusions, Inc., 2102 Calumet Rd., Valparaiso, Ind.
Impax, Inc., P.O. Box 5841, Ferguson 21, Mo.
Improved Seamless Wire Co., 775 Eddy St., Providence 5, R.I.
Imsande Screw Products Co., 3517 Cardiff Ave., Cincinnati 9, Ohio
Indar Corp., Indianapolis, Ind.
Independence Stove & Mfg. Co., Hayward & Cottage Sts., Independence, Mo.
Independent Galvanizing Co., 37 Verona Ave., Newark 4, N.J.
Indiana Brass Co., Inc., P.O. Box 113, Frankfort, Ind.
Indiana Forge & Machine Co., 3468 Watling St., East Chicago, Ind.
Indiana General Corp., General Ceramics Div., Keasbey, N.J.
Indiana Steel Products Co., Valparaiso, Ind.
Indiana Steel & Wire Co., Inc., 2200 E Jackson St., Muncie, Ind.
Indium Corp. of America (Ad p 172)
1676 Lincoln Ave., Utica 1, N.Y.
Indus Corp., 1815 Madison Ave., Indianapolis 25, Ind.
Industrial Chromium Corp., 109 Lyman St., Holyoke, Mass.
Industrial Equipment Co., 115 Ohio St., Minster, Ohio
Industrial Metal Protectives, Inc., 401 Homestead Ave., Dayton 8, Ohio
Industrial Mica Corp., 223 S Van Brunt St., Englewood, N.J.
Industrial Molded Products Co., Inc., Hwy. 53 at U.S. 14, Palatine, Ill.
Industrial Pipe & Supply Co., 5100 W 16th St., Cicero 50, Ill.
Industrial Plastic Fittings Co., 3891 W 150th St., Cleveland 11, Ohio
Industrial Plastics Corp., 816 W Beardsley Ave., Elkart, Ind.
Industrial Polychemical Service, P.O. Box 423, Gardena, Calif.
Industrial Precision Products, 325 N Hoyne Ave., Chicago 12, Ill.
Industrial Rayon Corp., 500 5th Ave., New York 36, N.Y.
Industrial Stainless Steels, Inc., 255 Bent St., Cambridge 41, Mass.
Industrial Synthetics Corp., 225 North Ave., Garwood, N.J.
Industrial Tectonics, Inc., 3686 Jackson Rd., Ann Arbor, Mich.
Industrial-Ferguson Foundry Corp., Route 22, Union, N.J.
Ingalls Iron Works Co., 620 4th Ave., Birmingham, Ala.
Ingersoll-Rand Co., Phillipsburg, N.J.
Ingram-Richardson, Inc., 1460 Jefferson Rd., Frankfort, Ind.
Ingram-Richardson Mfg. Co., P.O. Box 191, Beaver Falls, Pa.
Inland Mfg. Co., 1108 Jackson St., Omaha 2, Neb.
Inland Steel Co., 30 W Monroe St., Chicago 3, Ill.
Inshield Die & Stamping Co., 1931 Manhattan Blvd., Toledo 8, Ohio
Inspiration Consolidated Copper Co., 25 Broadway, New York 4, N.Y.
Instrument Parts Corp., Snowden Ave. & Water St., Ossining, N.Y.
Instrument Specialties Co., Inc. (Ad p 463)
244 Bergen Blvd., Little Falls, N.J.
Insulation Mfrs. Corp., 565 W Washington Blvd., Chicago 6, Ill.
Insulation Products Co., P.O. Box 5679, Pittsburgh 8, Pa.
Interchemical Corp., 67 W 44th St., New York 36, N.Y.
Angier Adhesives Div., 120 Potter St., Cambridge 42, Mass.
Finishes Div., 224 McWhorter St., Newark 5, N.J.
Interlake Mfg. Co., 13595 Helen Ave., Detroit 12, Mich.
International Balsa Corp., 100 Boyd Ave., Jersey City 4, N.J.
International Harvester Co., 180 Michigan Ave., Chicago, Ill.
International Minerals and Metals Corp., 11 Broadway, New York 4, N.Y.
Wisconsin Steel Co. Div., 180 N Michigan Ave., Chicago 1, Ill.
International Nickel Co., Inc., 67 Wall St., New York 5, N.Y.
Platinum Metals Div. (Ad pp 182-183)
67 Wall St., New York 5, N.Y.
International Optical Co., Inc., 47 Urban Ave., Westbury, L.I., N.Y.
International Packings Corp. (Ad p 416)
Bristol, N.H.
International Packings Corp., Bristol, N.H.
International Paper Co., Long-Bell Div., Longview, Wash.
International Powder Metallurgy Co., Inc., 439 W Main St., Ridgway, Pa.
International Silver Co., Eyelet Specialty Div., P.O. Box 179, Wallingford, Conn.
Interstate Drop Forge Co., 4051 N 27th St., Milwaukee 16, Wis.
Investment Casting Co., 60 Brown Ave., Springfield, N.J.
Iowa Malleable Iron Co., 9th & Kirkwood Sts., Fairfield, Iowa
Ironton Fire Brick Co., Box 536, Ironton, Ohio
Irvington Form & Tank Corp., 100 William St., New York 38, N.Y.
Irwin-Sensenich Corp., P. O. Box 311, Irwin, Pa.
Industrial & Furnace Car Div., P.O. Box 311, Irwin, Pa.
Isaacson Iron Works, 8531 E Marginal Way, Seattle 14, Wash.
Isocyanate Products, Inc., 900 Wilmington Rd., New Castle, Del.
Iten Fibre Co., Box 20, Ashtabula, Ohio

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Jackson Auto Radiator, 1515 Altgeld St., Chicago 14, Ill.
Jackson Steel Products, Inc., 32 Rodney St., Brooklyn 11, N.Y.
James Hill Mfg. Co., 20 Gordon Ave., Providence 5, R.I.
Jamestown Finishes, 125 Blackstone Ave., Jamestown, N.Y.
Jamestown Malleable Iron Corp., 3444 Blackstone Ave., Jamestown, N.Y.
Jamison Plastic Corp., 1255 Newbridge Rd., North Bellmore, L.I., N.Y.
Janney Cylinder Co., 7401 State Rd., Philadelphia 36, Pa.
Jaques Co., 67 Batterymarch St., Boston 10, Mass.
Jarco Metal Products, Portland Ave., Westbury, L.I., N.Y.
Jarl Extrusions, Inc. (Ad p 442)
Linden Ave., East Rochester, N.Y.
Jasco Aluminum Products Co., New Hyde Park, N.Y.
Jasper Lacquer Co., Inc., Vine St., Jasper, Ind.
Jelliff, C.O. Mfg. Corp., Pequot Rd., Southport, Conn.
Jelrus Precision Casting Corp., 136 W 52 St., New York, N.Y.
Jema-American, Inc., 181 South St., Newark 5, N.J.
Jersey Plastic & Die Casting Co., 151 Shaw Ave., Irvington, N.J.
Jervis Corp., 2900 Wilson Ave., Grandville, Mich.
Jessop Steel Co., 500 Green St., Washington, Pa.
Jet Specialties Co., Inc., 941 N Eastern Ave., Los Angeles, Calif.
Jobbins, William F. Inc., Aurora, Ill.
Johns-Manville Corp., 22 E 40th St., New York 16, N.Y.
Dutch Brand Div., 7800 Woodlawn Ave., Chicago 19, Ill.
Glass Textiles Div., 1810 Madison Ave., Toledo 2, Ohio
Johnson, A. & Co., Inc., 21 West St., New York 6, N.Y.
Johnson Bronze, S Mill St., New Castle 6, Pa.
Johnson Metal Hose, Inc., 10 Sperry St., Waterbury 20, Conn.
Johnson Plastic Corp., Box 312, Chagrin Falls, Ohio
Johnson Rubber Co., 111 Vine St., Middlefield, Ohio
Johnson, S.C. & Son, Inc., Racine, Wis.
Johnson Steel and Wire Co., Inc., 53 Wiser Ave., Worcester, Mass.
Johnston & Funk Titanium Corp., W Kemrow Ave., Wooster, Ohio
Johnstone Foundries, Inc., P.O. Box 549, Grove City, Pa.
Joiens Metal Products Co., 224 Sussex Ave., Newark 4, N.J.
Jones & Laughlin Steel Corp., 3 Gateway Center, Pittsburgh 30, Pa.
Stainless & Strip Div. (Ad pp 89, 96-97)
Stainless—P.O. Box 4606, Detroit 34, Mich.; Strip—1939 Teeghly St., Youngstown 1, Ohio
Jordan Co., 51st St. & Merrimac Ave., Chicago 38, Ill.
Jordan Machine Products, Inc., 3611 St. Aubin Ave., Detroit 7, Mich.
Jordan-Rogers Co., 640 N Cypress, Orange, Calif.
Joseff-Hollywood Co., 129 E Providencia, Burbank, Calif.
Joslyn Mfg. & Supply Co., 155 N Wacker Dr., Chicago 6, Ill.
William E. Pratt Foundry Div., 155 N Wacker Dr., Chicago 6, Ill.
Joslyn Pacific Co., 5100 District Blvd., Los Angeles 11, Calif.
Joslyn Stainless Steels, 155 N Wacker Dr., Chicago 6, Ill.
Joymont Plastics, Inc., 710 S State St., Girard, Ohio
Judd Industries, Inc., 3148 W 32 St., Cleveland 9, Ohio
Judsen Rubber Works, Inc., 4107 W Kinzie St., Chicago 24, Ill.

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K-D Mfg. Co., 435 Shaffer St., Cleburne, Tex.
K. & L. Plating Co., 535 E Mifflin St., Lancaster, Pa.
K S H Plastics, Inc., Hwy. 30, High Ridge, Mo.
KSM Products, Inc., Yale & Woodland Aves., Merchantville 8, N.J.
Kaiser Aluminum & Chemical Sales, Inc. (Ad p 419)
919 Michigan Ave., Chicago 11, Ill.
Kaiser Steel Corp., Kaiser Center, 300 Lakeside Dr., Oakland 12, Calif.
Kamin Die Casting & Mfg. Co. 3315 N Knox, Chicago 41, Ill.
Kanawha Mfg. Co., Charleston, W. Va.
Kansas City Hay Press Co., 801 Weeswether Rd., Kansas City 5, Mo.
Kanthal Corp., Amelia Pl., Stamford, Conn.
Kassel Export Co., Inc., 30 Jay St., Englewood, N.J.
Katelman Foundry & Mfg. Co., 238 S 11th St., Council Bluffs, Iowa
Kaufman Glass Co., 1209-21 French St., Wilmington 99, Del.
Kaweckl Chemical Co., 220 E 42nd St., New York 17, N.Y.
Kawneer Co., 1105 N Front St., Niles, Mich.
Kay-Bee Machine Products Co., 2776 S 34 St., Milwaukee 15, Wis.
Kay-Brunner Steel Products, Inc., 999 Meridian Ave., Alhambra, Calif.
Kaye-Tex Mfg. Corp., Kaykor Industries, Inc. Div., Yardville, N.J.
Keasbey & Mattison Co., Butler Ave., Ambler, Pa.
Keen Foundry Co., Inc., E Main & E Jerr Sts., Griffith, Ind.
Kees, F.D. Mfg. Co., 700 Park St., Beatrice, Neb.
Kelite Corp., Bldg. 15, 81 Industrial Rd., Berkeley Heights, N.J.
Keller Products, Inc., 37 Union, Manchester, N.H.
Kelley Mfg. Co., 4800 Clinton Dr., P.O. Box 17, Houston 1, Tex.
Kelly Foundry Co., 1704 Wharton St., Pittsburgh 3, Pa.
Kelsey-Hayes Co., 3600 Military Ave., Detroit, Mich.
Metals Div., New Hartford, N.Y.
Kendall Co., Walpole, Mass.
Andrews-Alderfer Div., 1055 Home Ave., Akron 10, Ohio
Fiber Products Div., Walpole, Mass.
Polyken Sales Div., 309 W Jackson Blvd., Chicago 6, Ill.
Kenmore Machine Products, Inc., 15 Depew Ave., Lyons, N.Y.

In contacting suppliers, please mention the Materials Selector Issue

Kennametal, Inc. (Ad p 306)
Lloyd Ave., Latrobe, Pa.
Kennatrack Corp., Engineered Nylon Products Div., 2530 By-Pass Rd., Elkhart, Ind.
Kennecott Copper Corp., 161 E 42nd St., New York, N.Y.
Chase Brass & Copper Co. Sub., Waterbury 20, Conn.
Okonite Co. Sub., 220 Passaic St., Passaic, N.J.
Kennedy Automatic Products, Inc., 406 S Linden St., Marshall, Mich.
Kenosha Automatic Products Co., P.O. Box 630, Kenosha, Wis.
Kensico Tube Co., Hubbell & RR Aves., Mt. Kisco, N.Y.
Kent Castings Corp., 200 Garden St., Grand Rapids 7, Mich.
Kent County Galvanizing Co., 15 Earlham Way, Hillsgrove 5, R.I.
Keolyn Plastics, Inc., 2731 N Pulaski Rd., Chicago 39, Ill.
Kerrco, Box 4178, Lincoln 7, Neb.
Kerr-Lakeside Industries, Inc., 21850 St. Clair Ave., Cleveland 17, Ohio
Kester Solder Co., 4201 Wrightwood Ave., Chicago 39, Ill.
Kewaunee Engineering Corp., N Main St., Kewaunee, Wis.
Keystone Carbon Co., 1935 State St., St. Marys, Pa.
Keystone Drawn Steel Co., Main & Bridge Sts., Spring City, Pa.
Keystone Forging Co., Northumberland, Pa.
Keystone Plastics, Inc., 282 Badger Ave., Newark, N.J.
Keystone Refining Co., Inc., Garden St., Philadelphia 37, Pa.
Keystone Steel & Wire Co., Peoria 7, Ill.
Kickhaefer Mfg. Co., 901 S 2nd St., Milwaukee 4, Wis.
King, Alfred B. Co., Devine St., North Haven, Conn.
King Fifth Wheel Corp., 2915 N 2nd Ave., Philadelphia 33, Pa.
King Laboratories, Inc., 127 Solar St., Syracuse 3, N.Y.
King-Seeley Corp., 720 Norris St., Ypsilanti, Mich.
Albert Lea Foundry-Queen Products Div., 902-910 E Main St., Albert Lea, Minn.
Almco Queen Products Div., 310 E Main St., Albert Lea, Minn.
Central Specialty Div., 720 Central Ave., Ypsilanti, Mich.
Kingsport Foundry & Mfg. Corp., E Sullivan & Main Sts., Kingsport, Tenn.
Kinkead Industries, Inc., 5860 N Pulaski Rd., Chicago 30, Ill.
Kiowa Corp., Marshalltown, Iowa
Kirchhof Patent Co., Inc., Dietze Bldg., 60-64 Union St., Newark 5, N.J.
Kirk, F.J. Co., Inc., 140 Brook St., Clinton, Mass.
Kirk, Morris P. & Son, 2700 S Indiana St., Los Angeles 23, Calif.
Kirk & Blum Mfg. Co., 3215 Forrer St., Cincinnati 9, Ohio
Kirkhill Rubber Co., Brea, Calif.
Kish Industries, Inc., 1301 N Turner St., Lansing 6, Mich.
Kleiner Metal Specialties, Inc., P.O. Box 185, Dunellen, N.J.
Klincher Locknut Corp., 2153 Hillside Ave., Indianapolis 18, Ind.
Kling Metal Spinning & Stamping Co., 245-247 Centre St., New York 13, N.Y.
Klinzing, A.F. Co., Inc., 921 A 2nd St., Milwaukee 4, Wis.
Klise Mfg. Co., 50 Cottage Grove St., Grand Rapids 2, Mich.
Knapp Mills, Inc., 23-17 Borden Ave., Long Island City 1, N.Y.
Knight, Maurice A., 171 Kelly Ave., Akron 9, Ohio
Knoedler Chemical Co., 651 High St., Lancaster, Pa.
Knowlton Bros., Inc. (Ad p 320)
215 Factory, Watertown, N.Y.
Kobel, W.R. Sheet Metal Products, 148 W 21st St., Ogden, Utah
Koch, H. & Sons, P.O. Box 125, Corte Madera, Calif.
Koehler Mfg. Co., 395 Lincoln St., Marlboro, Mass.
Koehring Co., Milwaukee, Wis.
Kohn Engineering Corp., 8830 S Telegraph Rd., Taylor Center, Mich.
Kopp Glass, Inc. (Ad p 309)
Swissvale, Pittsburgh 18, Pa.
Koppers Co., Inc., Koppers Bldg., Pittsburgh 19, Pa.
Plastics Div. (Ad pp 264-265)
Koppers Bldg., Pittsburgh 19, Pa.
Korhumel Steel and Aluminum Co., 2424 Oakton St., Evanston, Ill.
Koster-Keunen Mfg. Co., Inc., Bourne Blvd., Sayville, N.Y.
Kovar, John R. Mfg. Co., Inc., Bridge Square, Anoka, Minn.
Koven, L.O. & Brother, Inc., 154 Ogden Ave., Jersey City 7, N.J.
Kralay Plastic Pipe Co., Inc., 4710-20 E Washington Blvd., Los Angeles 22, Calif.
Kramer, C.P. Co., 9230 W Belmont Ave., Franklin Park, Ill.
Kramer, H. Co., Ajax Metal Div., 46 Richmond St., Philadelphia 23, Pa.
Kramer Bros. Foundry Co., 17 Dell St., Dayton 4, Ohio
Kraus Research Labs, Cockeysville, Md.
Kroh Wagner, 2331 N Pulaski Rd., Chicago 39, Ill.
Krone, Paul Die Casting Co., 1811 N Kostner Ave., Chicago 39, Ill.
Kropp Forge Co., 5301 W Roosevelt Rd., Chicago 50, Ill.
Krueger Fabricating Co., Inc., 257 W Badger Road, Madison 5, Wis.
Krueger & Hudepohl, Inc., 1041 Evans St., Cincinnati 4, Ohio
Kuhn & Jacob Molding & Tool Co., 1200 Southard Ave., Trenton 8, N.J.
Kurz Kasch, Inc., 1421 S Broadway, Dayton 1, Ohio
Kuss, R.L. & Co., Inc., 739 Foulke Ave., Findlay, Ohio
Kutztown Foundry & Machine Corp., Kutztown, Pa.
Kwikset Powdered Metal Products, 516 E Santa Ana St., Anaheim, Calif.

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L. & R. Mfg. Co., 577 Elm St., Arlington, N.J.
Laboratory Equipment Corp., Hilltop Rd. & Lakeview Ave., St. Joseph, Mich.
Laclede Steel Co., 1380 Arcade Bldg., St. Louis 1, Mo.
Laconia Malleable Iron Co., 71 Water St., Laconia, N.H.
Lacquer & Chemical Corp., 214 40th St., Brooklyn 32, N.Y.
Lacquer Products, Inc., 9001 Kinsman Rd., Cleveland 4, Ohio
Ladish Co., 5481 S Packard Ave., Cudahy, Wis.
La France Precision Casting Co., 29th & McKean St., Philadelphia 45, Pa.
Lake City Malleable Co., 5000 Lakeside Ave., Cleveland 14, Ohio
Lake Erie Foundry Co., 143 Fillmore Ave., Buffalo 10, N.Y.
Lake Mfg. Corp., 1070 East St., New Britain, Conn.
Lakeland Industries, Isle, Minn.
Lakeside Bronze, Inc., 90 Arthur St., Buffalo 7, N.Y.
Lakeside Malleable Casting Co., 1333 23rd St., Racine, Wis.
Lakewood Metal Products, Inc., 39 Cherry Ave., Waterbury 20, Conn.
Laminated Plastex Corp., 1427 W North St., Springfield, Ohio
Laminated Shim Co., 1600 Union St., Glenbrook, Conn.
Laminated Veneers Co., 102nd St. & 92nd Ave., Richmond Hill, N.Y.
Lamson Products Co., 1128 Poplar Pl., Seattle 44, Wash.
Lamson & Sessions Co., 5000 Tiedeman Rd., Cleveland 9, Ohio
Lamtex Industries, Inc., 66 Brooklyn Ave., Westbury, L.I., N.Y.
Lancaster Glass Corp., 220 W Main St., Lancaster, Ohio
Lancaster Malleable Castings Co., 1170 Lititz Ave., Lancaster, Pa.
Landau, J. & Co., Inc., Carlstadt, N.J.
Lang-Scharmann & Co., 206 W 1st St., Marshfield, Wis.
Langsenkamp, F.H. Co., 229 E South St., Indianapolis, Ind.
Langsenkamp-Wheeler Brass Works, Inc., South & Harmon Sts., Indianapolis, Ind.
Lansdale Porcelain Enamel Corp., 5th & Iron, Lansdale, Pa.
Lansing Stamping Co., Box 838, 1167 S Pennsylvania Ave., Lansing 4, Mich.
La Porte Foundry Co., 301 Truesdell Ave., La Porte, Ind.
Larkin Specialty Mfg. Co., 915 Linden Ave., South San Francisco, Calif.
Larson, W.O. Foundry Co., 799 Barchard, Grafton, Ohio
Larson, Charles E. & Sons, Inc., 2645-65 N Keeler Ave., Chicago 39, Ill.
Larson Tool & Stamping Co., Olive St., Attleboro, Mass.
La Salle Steel Co., P.O. Box 6800-A, Chicago 80, Ill.
Latrobe Die Casting Co., Latrobe, Pa.
Latrobe Steel Co. (Ad p 95)
Latrobe, Pa.
Lattimer Foundry and Machine Co., Lattimer Mines, Pa.
Lattner Bros. Machining Co., 650 E Troy, Ferndale 20, Mich.
Latwaitis, Ernest A., 102-09 Remsen Pl., Howard Beach 14, N.Y.
Lavelle Rubber Co., 424 N Wood St., Chicago 22, Ill.
Lavin, R. & Sons, Inc., 3426 S Kedzie Ave., Chicago 23, Ill.
Lawrence, L. Co., Inc., 292 Halsey St., Newark 2, N.J.
Lawrence Copper & Bronze Co., W New Castle St., Zilenpole, Pa.
Lawrence Laboratory, 1668 Euclid St., Santa Monica, Calif.
Lawrenceville Screw Co., 4920 Harrison St., Pittsburgh 1, Pa.
Lawson, F.H. Co., Evans & Whateley Sts., Cincinnati 4, Ohio
Lawton, C.A. Co., Broadway, DePere, Wis.
Laystrom Mfg. Co., 3900 W Palmer St., Chicago 47, Ill.
Lea Mfg. Co., 16 Cherry Ave., Waterbury 20, Conn.
Leach & Garner Co., Industrial Div., Leach & Garner Bldg., Attleboro, Mass.
Leader Iron Works, Inc., 2108 N Jasper St., Decatur, Ill.
Leake Engineering Co., P.O. Box 715-MS, Monroe, Mich.
Lebanon Steel Foundry, 1st Ave. & E Lehmen St., Lebanon, Pa.
LeBaron, E.L. Foundry, Box 746, Brockton, Mass.
Lee Bros. Foundry Co., Inc., P.O. Box 231 Anniston, Ala.
Lee Rubber & Tire Corp., Hector St., Conshohocken, Pa.
Republic Rubber Div., 1410 Albert, Youngstown 1, Ohio
Leed, H.A. Co., 1685 Diswell Ave., Hamden, Conn.
Lehigh, Inc., 1500 Lehigh Dr., Easton, Pa.
Lehigh Foundries Div., 1500 Lehigh Dr., Easton 1, Pa.
Lehigh Structural Steel Co., Allentown, Pa.
Leitelt Bros., Inc., 7721-31 S Chicago Ave., Chicago 19, Ill.
Lenape Hydraulic Pressing & Forging Co. (Ad p 462)
Box 536, West Chester, Pa.
Lester Castings Inc., Cannon & Aurora Rds., Bedford Heights, Ohio
LeTourneau, R. G., Inc., 2399 S MacArthur, Longview, Tex.
Letukas Foundry, Inc., Upland, Ind.
Levinson Steel Co., S 20th & Wharton St., Pittsburgh 3, Pa.
Lewco, 3901 Carew Tower, Cincinnati 2, Ohio
Lewis, G. B. Co. (Ad p 432)
4026 Montgomery St., Watertown, Wis.
Lewis, J.P. Co., Plastic Products Div., Beaver Falls, N.Y.
Lewis Bolt & Nut Co., 504 Malcolm Ave. SE, Minneapolis 14, Minn.
Lewis & Saunders, Lakeport, N.H.
Lewistown Foundry & Machine Co., 16 Elizabeth St., Lewistown, Pa.
Libbey - Owens - Ford Glass Co., Liberty Mirror Div. (Ad p 358)
851 3rd Ave., Brackenridge, Pa.
Liberty Foundry Co., 7600 Vulcan St., St. Louis 11, Mo.
Light Metals Corp., 1211 Monroe Ave NW, Grand Rapids, Mich.
Light Metals, Inc., 1100 E 24th St., Indianapolis 5, Ind.
Lignum-Vitae Products Corp., 98 Boyd Ave., Jersey City 4, N.J.
Lincoln Electric Co., 22801 St. Clair Ave., Cleveland 17, Ohio
Lincoln Foundry Corp., 2525 E 49th St., Los Angeles 58, Calif.
Lincoln Iron Works, 255 West St., Rutland, Vt.
Lincoln Machine Parts Corp., 732 E 144th St., New York 54, N.Y.
Lincoln Mfg. Co., Inc., 2617 W Fletcher St., Chicago 18, Ill.
Lincoln Molded Plastics, Inc., Corwin & Clinton Sts., Circleville, Ohio
Lincoln Steel Corp., 315 W 9th St., Lincoln 1, Neb.
Lindell Drop Forge Co., 2830 S Logan Blvd., Lansing 3, Mich.
Linden & Co., 80 Baker St., Providence 5, R.I.
Linderme Tube Co., 1500 219th St., Cleveland 17, Ohio
Link-Belt Co., 1700 Prudential Plaza, Chicago 1, Ill.
Linton Precision Casting Co., 917 N Nappanee St., Elkhart, Ind.
Litemetal Dicast, Inc., 1927 Wildwood Ave., Jackson, Mich.
Lithcote Corp., 5000 W Lake St., Melrose Park, Ill.
Lithium Corp. of America, Inc., 400 2nd Ave. S., Minneapolis 1, Minn.
Litho-Strip Corp., M. M. Young Div., 4800 S Kilbourn Ave., Chicago 32, Ill.
Littite Foundries, Inc., 2431 Conners St., Port Huron, Mich.
Little Falls Alloys, Inc. (Ad p 440)
189 Caldwell Ave., Paterson, N.J.
Littleford Bros. Inc., 453 E Pearl St., Cincinnati 2, Ohio
Littlestown Hardware & Foundry Co., Inc., Charles St., Littlestown, Pa.
Livingston-Tyler Products, 501 N 5th St., Hamilton, Ohio
Lloyd & Scott Brass Foundry, Inc., 2206 Tatnall St., Wilmington 99, Del.
Lock Joint Tube Co., Inc., 1400 Riverside Dr., South Bend 24, Ind.
Locke Machine Co., Center St., Andover, Ohio

Lockhart Iron & Steel Co., River Ave., McKees Rocks, Pa.
Lockport Mfg. Co., 1102 Collins St., Joliet, Ill.
Lockport Steel Fabricators, Inc., P.O. Box 67, Lockport, Ill.
Lodge Mfg. Co., RR & 6th, South Pittsburg, Tenn.
Lodi Iron Works, Inc., 820 S Sacramento, Lodi, Calif.
Loeffler, J.M. Machine Co., P.O. Box 195, Penndel, Pa.
Loewenthal Metals Corp., 947 Cullerton St., Chicago 8, Ill.
Lone Star Plastics Co., Inc., 124 Roberts Cutoff, Fort Worth, Tex.
Long Beach Iron Works, 2100 W Anaheim St., Long Beach 13, Calif.
Long Foundry Co., Hoquiam, Wash.
Lorain Automatic Screw Machine Co., Inc., 218 Connecticut, Lorain, Ohio
Lorain Brass Co., 639 Broadway, Lorain, Ohio
Loranger Mfg. Corp., 12-38 Clark St., Warren, Pa.
Lord Mfg. Co., Hughson Chemical Co. Div., Greengarden at 12th, Erie, Pa.
Los Angeles Galvanizing Co., Vernon Branch, P.O. Box 58411, Los Angeles 58, Calif.
Los Angeles Steel Casting Co., 6100 S Boyle Ave., Los Angeles 58, Calif.
Lowe Bros. Co., 424 E 3rd St., Dayton 2, Ohio
Lubenow, Arthur Co., 2015 S Kinnickinnic Ave., Milwaukee 7, Wis.
Lucas - Milhaupt Engineering Co. (Ad p 498)
5051 S Lake Dr., Cudahy, Wis.
Ludlow Plastics, 145 Rosemary St., Needham Heights 94, Mass.
Ludlow Valve Mfg. Co., Inc., Hudson River at Adams St., Troy, N.Y.
Lukens Steel Co., Coatesville, Pa.
Lumen Bearing Co., 197 Lathrop St., Buffalo 12, N.Y.
Luminous Resins, Inc., 166 W Washington St., Chicago 2, Ill.
Lundberg Screw Products Co., 2101 W Willow St., Lansing 4, Mich.
Lundquist Tool & Mfg. Co., Inc., 57 Jackson St., Worcester 8, Mass.
Lunn Laminates, Inc., Oakwood & W 11th Sts., Huntington Station, N.Y.
Luria Engineering Co., 1745 Easton Ave., Bethlehem, Pa.
Lus-Trus Corp., 884 Railroad St., Ypsilanti, Mich.
Lux Clock Mfg. Co., Inc., 95 Johnson St., Waterbury 20, Conn.
Luzerne Rubber Co., Muirhead Ave., Trenton 7, N.J.
Lynchburg Foundry Co., Castings Div., Courtland Bldg., Lynchburg, Va.
Lyndon Machine Products Co., Inc., 18564 Fitzpatrick Ave., Detroit 28, Mich.
Lynn Casting Corp., 3014 Floyd St., Burbank, Calif.

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M & S Mfg. Co., 220 Main St., Hudson, Mich.
Maas & Waldstein Co. (Ad p 353)
2121 McCarter Hwy., Newark 2, N.J.
Macaulay, H.C. Foundry Co., 811 Carlton St., Berkeley 10, Calif.
MacDermid Inc., 526 Huntingdon Ave., Waterbury 20, Conn.
Machine Products Corp., 125 Hollier Ave., Dayton, Ohio
Machinery Forging Co., 5430 Hamilton Ave., Cleveland 14, Ohio
Machinery Products Corp., 2020 N Major Ave., Chicago 39, Ill.
Machinery Products Co. of Lancaster, 317 E Fulton St., Lancaster 10, Pa.
Mac-It Parts Co., 275 E Liberty St., Lancaster, Pa.
Mack Molding Co., Wayne, N.J.
MacKenzie-Walton Co., 478 Pawtucket Ave., Pawtucket, R.I.
MacLean-Fogg Lock Nut Co. (Ad p 494)
5535 N Wolcott St., Chicago 40, Ill.
Maco Industries Inc., 6200 S Ashland Ave., Chicago 36, Ill.
Madin Plastics Inc., 370 North Ave., Cranford, N.J.
Madison Foundry Co., 935 Addison Rd., Cleveland 3, Ohio
Madison Kipp Corp., 201 Waubesa St., Madison 10, Wis.
Magic Chemical Co., 121 Crescent St., Brockton 2, Mass.
Magic Iron Cement Co., 5403 Bower Ave., Cleveland 27, Ohio
Magirl Foundry & Furnace Co., 413 E Oakland Ave., Bloomington, Ill.
Magline, Inc., 1960 Mercer, Pinconning, Mich.
Magna Mfg. Co., Inc., 4th Ave., Haskell, N.J.
Magnesium Co. of America, 5222 Indianapolis Blvd., East Chicago, Ill.
Magnesium Elektron, Inc., 630 5th Ave., New York 20, N.Y.
Magnesium Products of Milwaukee, Inc., 740 N Plankinton Ave., Milwaukee 3, Wis.
Magnetic Core Corp., John & Lawrence Sts., Newburgh, N.Y.
Magnetic Powders, Inc., Fairview Ave., Johnsonburg, Pa.
Magnetic Stamping Co., Fairview Ave., Johnsonburg, Pa.
Magnode Products, Inc., P.O. Box 292, Trenton, Ohio
Magnolia Metal Co., 800 McCarter Hwy., Newark 4, N.J.
Magnuson Products Corp., 50 Court St., Brooklyn 1, N.Y.
Mahon, R.C. Co., 6565 E 8 Mile Rd., Detroit 34, Mich.
Main Screw Machine Products, Inc., 58 Lafayette St., Waterbury, Conn.
Malleable Iron Fittings Co., Branford, Conn.
Mallory, P.R. & Co., Inc., 3033 E Washington St., Indianapolis 6, Ind.
Mallory, P.R. Plastics, Inc., 3670 Milwaukee Ave., Chicago 41, Ill.
Mallory-Schwarzkopf Metals, Inc., 320 Yonkers Ave., Yonkers, N.Y.
Malone Bronze Powder Works, Inc., Malone, N.Y.
Malone Metal Powders, Inc., Rte. 202, Flemington, N.J.
Maloney, F.H. Co., 2301 Texas Ave., P.O. Box 1777, Houston 1, Tex.
Malvern Brick & Tile Co., P.O. Box 415, Malvern, Ark.
Manco Products, Inc., 2401 Schaefer Rd., Melvindale, Mich.
Manganese Steel Forge Co., Richmond St. & Castor Ave., Philadelphia 34, Pa.
Manhattan Adhesives Corp., 425 Greenpoint Ave., Brooklyn 22, N.Y.
Mannesmann-Easton Plastic Products Co., Inc., 900 Line St., Easton, Pa.
Manor Die Cast Corp., P.O. Box 386, Bedford, Ohio
Mansfield Brass & Aluminum Corp., 287 N Diamond St., Mansfield, Ohio
Mansol Ceramics Co., 140 Little St., Belleville 9, N.J.
Mantel Screw Products Co., 3200 W Vliet St., Milwaukee 8, Wis.
Manufacturers Corp., 104 Ausdale Ave., Mansfield, Ohio
Manufacturers & Fabricators, Inc., Filbert St., Elyria, Ohio
Manufacturers Iron Foundry, Inc., 785 Union Ave., Bridgeport, Conn.
Manufacturers Service, Inc., 11440 Brookpark Rd., Cleveland 30, Ohio
Marblette Corp., 37-31 30th St., Long Island City 1, N.Y.
Markal Co., 3052 W Carroll Ave., Chicago 12, Ill.
Marlane Development Co., Inc., 153 E 26th St., New York 10, N.Y.
Marquette Mfg. Co., Inc., 307 E Hennepin Ave., Minneapolis, Minn.
Marquette Metal Products Co., 1145 Galewood Dr., Cleveland 10, Ohio
Marsco Mfg. Co., 2901 S Halsted St., Chicago 8, Ill.
Marshall Car Wheel & Foundry Co., Inc., 605 Greenwood Ave., Marshall, Tex.
Martin Rubber Co., Inc., Long Branch Ave., Long Branch, N.J.
Masco Screw Products Co., 12825 Ford Rd., Dearborn, Mich.
Masland Duraleather Co., Amber & Willard Sts., Philadelphia 34, Pa.
Mason Envelope Co., Inc., 536 Broadway, New York 12, N.Y.
Masonite Corp., 111 W Washington St., Chicago 2, Ill.
Massachusetts Screw Mfg. Co., 9 W 3rd St., South Boston 27, Mass.
Massillon Steel Casting Co., Box 388, Massillon, Ohio
Master Chrome Service, Inc., 5709 Herman Ave., Cleveland 2, Ohio
Matthiessen & Hegeler Zinc Co., 9th & Sterling Sts., La Salle, Ill.
May, Inc., 5803 Alice Rd., Houston 5, Tex.
Maynard Mfg. Co., 22755 Shakespeare Ave., East Detroit, Mich.
Mayon Plastics, 415 17th Ave. N, Hopkins, Minn.
Mayville Metal Products Co., 104 Highland St., Mayville, Wis.
Maywood Chemical Works, 111 W Hunter Ave., Maywood, N.J.
Maze, W.H. Co., 1207 Water St., Peru, Ill.
McCarter Iron Works, Inc., Norristown, Pa.
McCrady Refractories, Inc., P.O. Box 11566, Pittsburgh 38, Pa.
McDanel Refractory Porcelain Co. (Ad p 308)
510 9th Ave., Beaver Falls, Pa.
McDougall Butler Co., Inc., 2929 Main St., Buffalo 14, N.Y.
McDowell Mfg. Co., 301 Stanton Ave., Pittsburgh 9, Pa.
McDowell-Wellman Cos., 113 St. Clair Ave. NW, Cleveland 14, Ohio
McGean Chemical Co., 1040 Midland Bldg., Cleveland 15, Ohio
McGee Chemical Co., Inc., 8000 W Chester Pike, Upper Darby, Pa.
McGraw-Edison Co., 5201 W 65th St., Chicago, Ill.
Illinois Edison Porcelain Div., Macomb, Ill.
Line Material Industries Div., N Burson St., East Stroudsburg, Pa.
Mc Gregor-Michigan Corp., 5818 Rivard, Detroit 11, Mich.
McInnes Steel Co., 441 E Main St., Corry, Pa.
McKay Co., 481 McKay Bldg., Pittsburgh, Pa.
McKinney Mfg. Co., 1715 Liverpool St., Pittsburgh 33, Pa.
McLanahan & Stone Corp., 200 Wall St., Hollidaysburg, Pa.
McLouth Steel Corp., 300 S Livernois Ave., Detroit 17, Mich.
McMahon Bros. Machine Works, Inc., 3200 S 61st Court, Cicero 50, Ill.
McNally Pittsburg Mfg. Co., P.O. Drawer D., Pittsburg, Kan.
Meaden Screw Products Co., 3010 S Kilbourn Ave., Chicago 23, Ill.
Meadville Malleable Iron Co., Meadville, Pa.
Mearl Corp., 124 E 40th St., New York 16, N.Y.
Measuregraph Co., 4245 Forest Park Blvd., St. Louis 8, Mo.
Mechanical Art Works, Inc., 96-98 Monroe St., Newark 5, N.J.
Mechanical Felt & Textiles Co., 50 W 18th St., Weehawken, N.J.
Mechanical Leathers, Inc., 2204 E Butler St., Philadelphia 37, Pa.
Mechanical Plating Co., 1500-26 W Hubbard St., Chicago 22, Ill.
Mechanical Rubber Products Co., Warwick, N.Y.
Medico Industries, Inc., 11-13 Tompkins St., Pittston, Pa.
Meehanite Metal Corp. (Ad p 461)
714 North Ave., New Rochelle, N.Y.
Meeker Foundry Co., Newark 4, N.J.
Meier Screw Products & Mfg. Co., 19361 Sherwood Ave., Detroit, Mich.
Meico Wire Products, 4407 San Fernando Rd., Glendale 4, Calif.
Melling Forging Co., 1709 Thompson St., Lansing 3, Mich.
Melray Mfg. Co., 9511 W. River St., Schiller Park, Ill.
Mercast Mfg. Corp., 2620 1st St., La Verne, Calif.
Merit Screw Machine Products Co., Inc., 4847 W Lake St., Chicago 44, Ill.
Merit Specialties Co., Inc., 203-205 E Davis St., St. Louis 11, Mo.
Merix Chemical Co., 2234 E 75th St., Chicago 49, Ill.
Merrimac Brass, 22 High St., Merrimac, Mass.
Merriman Bros., Inc., 185 Amory St., Boston 30, Mass.
Merz Machine & Tool Works, 920 N Main St., Crown Point, Ind.
Mesa Plastics Co., 12270 Nebraska Ave., Los Angeles 25, Calif.
Metal Carbides Corp., 107 E Indianola Ave., Youngstown 5, Ohio
Metal Coating Corp., 1215 W 37th St., Chicago 9, Ill.
Metal Finishers, Inc., 78 S Franklintown Rd., Baltimore 23, Md.
Metal Goods Corp., 8800 Page Blvd., St. Louis 14, Mo.
Metal Hydrides, Inc., 12 Congress St., Beverly, Mass.
Metal Mold Magnesium Corp., 95 Hamilton St., Cedarburg, Wis.
Metal Parts & Stamping Co., 1120 Eastern Ave., Cincinnati, Ohio
Metal Powder Products, Inc., P.O. Box 189 M, Logan, Ohio
Metal Textile Corp., 647 E 1st Ave., Roselle, N.J.
Metal Trims, Inc., Livingston Rd., Jackson, Miss.
Metal & Thermit Corp. (Ad p 357)
Rahway, N.J.
Metal-Cladding, Inc., P.O. Box 544, North Tonawanda, N.Y.
Metallized Carbon Co., 19 S Water St., Ossining, N.Y.
Metallizing Co. of America, 3520 W Carroll Ave., Chicago 24, Ill.
Metallizing Co. of Los Angeles, Inc., 1233 S Boyle Ave., Los Angeles 23, Calif.
Metallizing Engineering Co., Inc. (Ad pp 351, 360)
Prospect Ave., Westbury, N.Y.
Metallurgical Products Co., 35th & Moore Sts., Philadelphia, Pa.
Metallo Gasket Co., 21 Bethany St., New Brunswick, N.J.
Metalplate Co., Inc., 757 North 44th St., Birmingham 6, Ala.
Metals Disintegrating Co. (Ad p 456)
P.O. Box 290, Elizabeth, N.J.
Metalweld, Inc., Protective Coating Div., Scotts Lane & Abbottsford Ave., Philadelphia, Pa.
Metaplast Process, Inc., 34-51 56th St., Woodside, N.Y.

In contacting suppliers, please mention the Materials Selector Issue

Met-L-Wood Corp., 6755 W 65th St., Chicago 38, Ill.

Metropolitan Iron Foundry, 890 Metropolitan Ave., Brooklyn 11, N.Y.

Metz Refining Co., 369 Mulberry St., Newark 2, N.J.

Meyer, J. & Sons, Inc., 4321 N 4th St., Philadelphia 40, Pa.

Mica Corp., 4031 Elenda St., Culver City, Calif.

Mica Fabricating Co., 53 Central Ave., Rochelle Park, N.J.

Micacraft Products, Inc., 701 McCarter Hwy., Newark, N.J.

Micheiman Chemicals, Inc., 6316 Wiehee Rd., Cincinnati, Ohio

Michigan Chemical Corp., Rare Earths & Thorium Div., St. Louis, Mich.

Michigan Chrome & Chemical Co., 8615 Grinnell Ave., Detroit 13, Mich.

Michigan Leather Products Co., 6307 E Lafayette Ave., Detroit 7, Mich.

Michigan Pipe Co., Saran Lined Pipe Co. Div., 2415 Burdette Ave., Ferndale 20, Mich.

Michigan Plastic Products, Inc., Robbins Rd. Grand Haven, Mich.

Michigan Seamless Tube Co., South Lyon, Mich.

Michigan Wire Cloth Co., 2100 Howard St., Detroit 16, Mich.

Mico Corp., 4031 Elenda, Culver City, Calif.

Micro Metallic Corp., 30 Sea Cliff Ave., Glen Cove, N.Y.

Micro Products Corp., 4116-18 Olive St., St. Louis 8, Mo.

Micro-Metals Co., 52 E Montecito Ave., Sierra Madre, Calif.

Midland Adhesive & Chemical Corp., 2600 Goodrich, Ferndale 20, Mich.

Midland Industrial Finishes Co., E Water St., Waukegan, Ill.

Midland Pipe & Supply Co., 2829 S 61st St., Cicero 50, Ill.

Midland Screw Corp., 3638 S Kedzie Ave., Chicago 32, Ill.

Mid-States Rubber Products, Inc., 1230 Race St., Princeton, Ind.

Mid-States Steel & Wire Co., Crawfordsville, Ind.

Midvale-Heppenstall Co., Nicetown, Philadelphia 40, Pa.

Midwest Molding & Mfg. Co., Gurnee, Ill.

Midwest Piping Co., Inc., 2nd & Barry Sts., St. Louis 4, Mich.

Midwest Plastic Products Co., 1801 Chicago Rd., Chicago Heights, Ill.

Midwest Precision Castings Co., 1070-903 Quincy Ave., Cleveland 6, Ohio

Midwest Rubber Co., 14273 E 9 Mile Rd., East Detroit, Mich.

Mid-West Screw Products Co., 3662 Park Ave., St. Louis 10, Mo.

Midwest Screw Products, Inc., 1641 Colt Ave., East Cleveland 12, Ohio

Midwest Sintered Products Corp., 13606 S Halsted St., Chicago 27, Ill.

Midwest Stamping & Mfg. Co., Krauss Rd., Bowling Green, Ohio

Mid-West Wire Products Co., Inc., 2555 Fenkell Ave., Detroit 38, Mich.

Midwestern Foundries, Inc., 614 E Quincy, Garrett, Ind.

Milford Automatics, Inc., 1553 Boston Post Rd., Milford 15, Conn.

Milford Rivet & Machine Co., Milford, Conn.

Milled Screw Product Co., 2016-2026 W Lake St., Chicago 12, Ill.

Miller Co., 99 Center St., Meriden, Conn.

Miller-Stephenson Chemical Co., Inc., 18 Marshall St., South Norwalk, Conn.

Millers' Brass Fitting Co., Inc., 30 Main St., Brooklyn 1, N.Y.

Milwaukee Aluminum & Brass Foundry, 643 S 2nd St., Milwaukee 4, Wis.

Milwaukee Die Casting Co., 4134 N Holton St., Milwaukee 12, Wis.

Milwaukee Forge & Machine Co., 1532 E Oklahoma Ave., Milwaukee 7, Wis.

Milwaukee Machine Products Co., 3889 N 1st St., Milwaukee 12, Wis.

Milwaukee Malleable & Grey Iron Works, 2773 S 29th St., Milwaukee 46, Wis.

Milwaukee Stamping Co., 800-S 72nd St., Milwaukee 14, Wis.

Milwaukee Valve Co., 2375 S. Burrell St., Milwaukee 7, Wis.

Minimax Co., 5905 N Clark St., Chicago 26, Ill.

Minneapolis Electric Steel Castings Co., 3800 NE 5th St., Minneapolis 21, Minn.

Minneapolis Plastic Molders, Inc., 5742 Nicollet Ave. S, Minneapolis 19, Minn.

Minnesota Mining & Mfg. Co., 900 Bush Ave., St. Paul 6, Minn.

Adhesives, Coatings & Sealers Div., 411 Piquette Ave., Detroit 2, Mich.

Chemical Div., 900 Bush Ave., St. Paul 16, Minn.

Irvington Varnish & Insulator Div., Irvington N.J

Mica Insulator Div., 797 Broadway, Schenectady 1, N.Y.

Reinforced Plastics Div. (Ad pp 258-259)

900 Bush Ave., St. Paul 6, Minn.

Zenith Plastics Co. Div., Box 91, Gardena, Calif.

Minnesota Paints, Inc., 1101 S 3rd St., Minneapolis 15, Minn.

Minnesota Plastics Corp., 45 E Maryland Ave., St. Paul 3, Minn.

Minnesota Rubber Co., 3630 Wooddale Ave., Minneapolis 16, Minn.

Miracle Adhesives Corp., 250 Pettit Ave., Bellmore, L.I., N.Y.

Mirro Aluminum Co., 1512 Washington St., Manitowoc, Wis.

Misco Precision Casting Co., 116 W Gibbs, Whitehall, Mich.

Misner Corp., 940 N 23rd St., Omaha 2, Neb.

Missouri Boiler & Sheet Works, 23rd & Papin Sts., St. Louis 3, Mo.

Missouri Diecasting Co., 1411 N 17, St. Louis 6, Mo.

Missouri Rolling Mill Corp., 6800 Manchester Ave., St. Louis 10, Miss.

Missouri Steel Castings Co., 905 E 3rd St., Joplin, Mo.

Mitchell & Scott Machine Co., Inc., 1841 Ludlow Ave., Indianapolis 7, Ind.

Mitchell-Bradford Chemical Co., Wampus Lane, Milford, Conn.

Mobay Chemical Co., Penn Lincoln Parkway W, Pittsburgh 5, Pa.

Mobile Paint Mfg. Co., Inc., P.O. Box 1686, Mobile, Ala.

Moccasin Bushing Co., 2000 Chestnut St., Chattanooga 8, Tenn.

Moczik Tool & Die Works, 9511 Grinnell, Detroit 13, Mich.

Model Brass Co., Inc., 232-40 E Decatur St., Decatur, Ill.

Modern Brass Foundry & Mfg. Co., 157 Thurman St., Columbus 6, Ohio

Modern Plastics Corp., 489 N Shore Dr., Benton Harbor, Mich.

Modern Plating Corp., 121-129 S Hancock Ave., Freeport, Ill.

Modern Screw Products Co., 2307 N 9th St., St. Louis 6. Mo.

Modiglass Fibers, Inc., P.O. Box 86, Bremen, Ohio

Mohawk Foundries, Inc., 55 1st Ave., Berea, Ohio

Moldcast Products, Inc., Pacific St., Newark 5, N.J.

Molded Fiber Glass Co., 4401 Benefit Ave., Ashtabula, Ohio

Moldex, 747 5th Ave., New York 22, N.Y.

Moline Iron Works, 130 2nd, Moline, Ill.

Moline Malleable Iron Co., St. Charles 5, Ill.

Molybdenum Corp. of America, Washington, Pa.

Monarch Aluminum Mfg. Co., 9205 Detroit Ave., Cleveland 2, Ohio

Monarch Products Co., Leake Stamping Div., 1259 E 1st St., Monroe, Mich.

Monarch Tool & Mfg. Co., 105 E 4th St., Covington, Ky.

Mono-Sol Corp., 407 County Line Rd., Gary, Ind.

Monroe Steel Castings Co., 917 W Front, Monroe, Mich.

Monsanto Chemical Co., 600 Monsanto Ave., Springfield, Mass.

Inorganic Chemicals Div., 800 N Lindbergh Blvd., St. Louis 66, Mo.

Organic Chemicals Div., Lindbergh & Olive St. Rd., St. Louis 24, Mo.

Plastics Div., Springfield 2, Mass.

Montague Machine Co., 15th St., Turners Falls, Mass.

Monteath, J.H. Co., 2504 Park Ave., New York, N.Y.

Moody Machine Products Co., Inc., 42 Dudley St., Providence 5, R.I.

Moore, George W., Inc., 100 Beaver St., Waltham 54, Mass.

Moore, Samuel & Co., Mantua, Ohio

Moore Dry Dock Co., Adeline St., Oakland 23, Calif.

Morganite, Inc., 3302 48th Ave., Long Island City 1, N.Y.

Morningstar-Paisley, Inc., 630 W 51st St., New York 19, N.Y.

Morrell, George Corp., P.O. Box 155, Muskegon Heights, Mich.

Morrison Steel Products, Inc., 601 Amherst St., Buffalo 7, N.Y.

Morrisville Foundry Co., Inc., Morrisville, Vt.

Morse, Fred W. Co., 309 S Main St., Providence 3, R.I.

Morton Mfg. Co., 5125 W Lake St., Chicago 44, Ill.

Mosinee Paper Mills Co., Mosinee, Wis.

Mott Metallurgical Corp. (Ad p 466)

272 Huyshope Ave., Hartford, Conn.

Mount Vernon Die Casting Corp., Southfield Ave., Stamford, Conn.

Mount Vernon Furnace & Mfg. Co., Mount Vernon, Ill.

Moxness Products, Inc. (Ad p 460)

1914 Indiana St., Racine, Wis.

Muehlstein, H. & Co., Inc., 60 E 42nd St., New York 17, N.Y.

Mueller Brass Co. (Ad p 455)

1925 Lapeer Ave., Port Huron, Mich.

Mueller Machine Products, Inc., 3807 S Packard Ave., Milwaukee 7, Wis.

Multiple Extrusions, Inc., 1150-1200 E 8th St., Winona, Minn.

Muncie Malleable Foundry Co., E Highland Ave., Muncie, Ind.

Muncie Metal Spinning, Inc., 1012 E 20th St., Muncie, Ind.

Mundt, Charles & Sons, 53 Fairmount Ave., Jersey City 4, N.J.

Murray, A.B. Co., Inc., P.O. Box 476, Elizabeth, N.J.

Murray Tube Works, Inc., P.O. Box 476, Elizabeth, N.J.

Muskegon Piston Ring Co., Sparta Foundry Div., Sparta, Mich.

Mycalex Corp. of America (Ad pp 323-324)

125 Clifton Blvd., Clifton, N.J.

Synthetic Mica Co. Div., 20 Passaic Ave., Caldwell, N.J.

Mystik Adhesive Products, Inc., 2635 N Kildare Ave., Chicago 39, Ill.

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Naige Co., Inc., P.O. Box 365, Rochester 2, N.Y.

Napoleon Products Co., 410 Fillmore St., Napoleon, Ohio

Narmco Industries, Inc., Narmco Materials Div., 600 Victoria St., Costa Mesa, Calif.

Narragansett Boiler Works, Inc., 614 S Main St., Providence 3, R.I.

National Acme Co., 170 E 131st St., Cleveland 8, Ohio

National Aluminum Co., 1133 Alum Creek Dr., Columbus 9, Ohio

National Aluminum Co., Inc., 1912 Edgewood Ave., Racine, Wis.

National Aluminum & Brass Foundry, Inc., P.O. Box 179, Independence, Mo.

National Aluminum Mfg. Co., 720 Park Ave., Peoria, Ill.

National Beryllia Corp., 4501 Dell Ave., North Bergen, N.J.

National Brass Works, Inc., 2140 E 25th St., Los Angeles 58, Calif.

National Casein Co., 601 W 80th St., Chicago 20, Ill.

National Copper & Smelting Co., 1862 E 123rd St., Cleveland 6, Ohio

National Die Casting Co., 3635 W Touhy Ave., Chicago 45, Ill.

National Distillers & Chemical Corp., U. S. Industrial Chemicals Co. Div., 99 Park Ave., New York 16, N.Y.

National Felt Co., 76 Summer St., Boston 10, Mass.

National Forge & Ordnance Co., Irvine, Warren County, Pa.

National Galvanizing Co., Neville Island, Pittsburgh 25, Pa.

National Gasket & Washer Mfg. Co., Inc., 124 E 25th St., New York 10, N.Y.

National Grey Iron Foundry, Belvidere, Ill.

National Impacted Metal Corp., Box 726, New Albany, Miss.

National Lead Co., 111 Broadway, New York 6, N.Y.

Doehler-Jarvis Div., 1945 Smead Ave., Toledo, Ohio

Goldsmith Bros. Div., 111 N Wabash Ave., Chicago 2, Ill.

Titanium Alloy Mfg. Div., 2950 Hyde Park Blvd., Niagara Falls, N.Y.

Zirconium Metals Corp of America Sub. (Ad p 430)

111 Broadway, New York 6, N.Y.

National Lead Construction Co., Inc., P.O. Box 133, Haddonfield, N.J.

National Lock Co., 1902 7th St., Rockford, Ill.

Fastener Div., 4500 Kishwaukee, Rockford, Ill.

National Lock Washer Co., 40 Hermon St., Newark 5, N.J.

National Machine Products Co., 44225 Utica Rd., Utica, Mich.

National Malleable & Steel Castings Co., 10600 Quincy Ave., Cleveland 6, Ohio

National Mfg. Corp., 153 Fillmore Ave., Tonawanda, N.Y.

National Metal Products Co., 2 Gateway Center, Pittsburgh 22, Pa.

National Molded Products, Inc., 40 St. Marys St., St. Marys, Pa.

National Moldite Co., 250 South St., Newark 5, N.J.

National Paint & Manganese Co., Lynchburg, Va.

National Research Corp., 70 Memorial Dr., Cambridge 42, Mass.

National Screw & Mfg. Co., 2440 E 75th St., Cleveland 4, Ohio

National Starch & Chemical Corp., Structural Products Div., 750 3rd Ave., New York 17, N.Y.

National Steel Corp., Grant Bldg., Pittsburgh, Pa.

Enamelstrip Corp. Sub., 20th & Hamilton Sts., Allentown, Pa.

Great Lakes Steel Corp., Detroit 29, Mich.
Weirton Steel Co., Weirton, W. Va.
National Steel & Shipbuilding Corp., Harbor Dr. & 28th St., San Diego 12, Calif.
National Supply Co., 2 Gateway Center, Pittsburgh 22, Pa.
National Tank Co., Wells & Sandspring Rd., Tulsa, Okla.
National Vulcanized Fibre Co. (Ad p 249)
Box 311, Wilmington 99, Del.
National-Standard Co. (Ad p 421)
601 N 8th St., Niles, Mich.
Athenia Steel Div., Clifton Ave., Clifton, N.J.
Reynolds Wire Div., 809 E 2nd St., Dixon, Ill.
Worcester Wire Works Div., 70 James St., Worcester, Mass.
National-U. S. Radiator Corp., Plastic Metals Div., 4459 Bridge St., Johnstown, Pa.
Neenah Foundry Co., Winneconne Ave., Neenah, Wis.
Neilson Chemical Co., 2300 Gainsboro, Detroit (Ferndale) 20, Mich.
Nesbitt Industries, Inc., 1823 Milwaukee Ave., Chicago 47, Ill.
Nesor Alloy Products Co., 282 Halsey St., Newark, N.J.
New Britain Machine Co., South St., New Britain, Conn.
New England Brass Co., 16 Park St., Taunton, Mass.
New England Die Casting Co., 445 Front Ave., West Haven, Conn.
New England Electrical Works, Inc., 365 Main St., Lisbon, N.H.
New England Laminates Co. (Ad p 281)
P.O. Box 43, 481 Canal St., Stamford, Conn.
New England Smelting Works, Inc., 502 Union St., West Springfield, Mass.
New Haven Copper Co., Main St., Seymour, Conn.
New Haven Screw Machine Products, Inc., 561 Boston Post Rd., Milford, Conn.
New Jersey Aluminum Extrusion Co., Inc., Jersey Ave., New Brunswick, N.J.
New Jersey Metals Co., 712 Rockefeller St., Elizabeth 2, N.J.
New Jersey Zinc Co. (Ad pp 452-453)
160 Front St., New York 38, N.Y.
New Products Corp., 448 North Shore Ave., Benton Harbor, Mich.
New York Air Brake Co., Kinney Mfg. Div., 3529 Washington St., Boston 30, Mass.
New York Iron Roofing & Corrugating Co., Inc., 94 1st St., Jersey City 2, N. J.
Newage Industries, Inc., 222 York Rd., Jenkintown 3, Pa.
Newark Wire Cloth Co. (Ad p 454)
351 Verona Ave., Newark 4, N.J.
Newman Bros., Inc., 670 W 4th St., Cincinnati, Ohio
Newman-Crosby Steel Co., Deane St., Pawtucket, R.I.
Newport Steel Corp., 9th & Thomas Sts., Newport, Ky.
Newth Rubber Co., County Rd., Barrington, R.I.
Newton-New Haven Co., 680 3rd Ave., West Haven, Conn.
Newtown Mfg. Co., Newtown, Conn.
Ney, J.M. Co., Industrial Div., P.O. Box 990, Hartford 1, Conn.
Nichols, L.O. & Son Mfg. Co., 1625 Locust St., Kansas City 8, Mo.
Nichols Wire & Aluminum Co., 1725 Rockingham Rd., Davenport, Iowa
Nicolet Industries, Inc., 70 Pine St., New York 5, N.Y.
Nicoud Mfg. Co., 3220 Grand Ave., Chicago 51, Ill.
Nigg Engineering Corp., 545 N 2nd Ave., Covina, Calif.
Nikoh Tube Co., 5000 S Whipple St., Chicago 32, Ill.
Nikolas, G.J. & Co., Inc., 2890 Washington Blvd., Bellwood, Ill.
Nilsen Mfg. Co., Electronicast Div., 21 N Church St., Addison, Ill.
Nippert Electric Products Co., 1759 W Mound St., Columbus 23, Ohio
Nixon Nitration Works, Nixon, N.J.
Noble & Wood Machine Co., 1st St., Hoosick Falls, N.Y.
Noera Mfg. Co., 236 Grand St., Waterbury 20, Conn.
Noland Tank & Galvanizing Co., 705 Merritt Ave., Nashville 4, Tenn.
Nolte Screw Machine Products Co., 1534-36 Freeman Ave., Cincinnati 14, Ohio
Noone Industrial Fabrics Div., Kenwood Mills, Rensselaer, N.Y.
Nopco Chemical Co., 1st & Essex Sts., Harrison, N.J.
Norcross, C.S. & Sons Co., Dean & Davis Sts., Bushnell, Ill.
Norgren-Stemac, Inc., 5400 S Delaware, Littleton, Ohio
Norrich Plastics Corp., 107-109 W 18th St., New York, N.Y.
Screw Machine Products Div., 107-109 W 18th St., New York, N.Y.
North American Asbestos Corp., Board of Trade Bldg., Chicago 4, Ill.
North American Aviation, Inc., Navan Products, Inc. Sub., 900 N Sepulveda, El Segundo, Calif.
North American Cement Co., Designers Metals Div., 650 Hoffman St., Hammond, Ind.
North American Phillips Co., Inc., Elmet Div., Lewiston, Me.
North American Refractories Co., 1012 National City-E 6th Bldg., Cleveland 14, Ohio
North & Judd Mfg. Co., Wilcox-Crittenden Div., Middletown, Conn.
North Wales Foundry Co., Inc., Wessahickon Ave., North Wales, Pa.
Northern Malleable Iron Co., 867 Forest St., St. Paul 6, Minn.
Northern Plastics Corp., 2nd & Market St., La Crosse, Wis.
Northwest Automatic Products Corp., 1770 Linden Ave., Minneapolis 3, Minn.
Northwest Chemical Co., 9310 Roselawn Ave., Detroit 4, Mich.
Northwest Plastics Industries, Inc., 2040 15th Ave. W, Seattle 99, Wash.
Northwestern Steel & Wire Co., Ave. B & Wallace St., Sterling, Ill.
Norton Co. (Ad p 348)
New Bond St., Worcester 6, Mass.
Norwalk Powdered Metals, Inc., P.O. Box 271, Muller Park, Norwalk, Conn.
Norwich Leather Co., 685 N Main St., Norwich, Conn.
Nosco Plastics Co., 17th & Gasgo, Erie, Pa.
Nuclear Corp. of America, Research Chemicals Div., Box 431, Burbank, Calif.
Nuclear Metals, Inc., Concord, Mass.
Nukem Products Corp., 111 Colgate Ave., Buffalo 20, N.Y.
Nu-Ply Corp., Bemidji, Minn.
Nutmeg Crucible Steel Co., Elm & Harbor Sts., Branford, Conn.
Nutmeg Screw Machine Products Co., Wolcott Rd., Wolcott, Conn.
Nutt-Shel Co., Inc., 2701 S Harbor Blvd., Santa Ana, Calif.
Nylok Corp., 611 Industrial Ave., Paramus, N.J.
Nylok-Detroit, 1100 N Woodward, Birmingham, Mich.
Nylon Molded Products Corp., Garrettsville, Ohio
Nyloncraft, Inc., 218 McKinley Hwy. W, Mishawaka, Ind.

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Oak Hill Foundry & Machine Works, Box 278, Oak Hill, Ohio
Oakes Bronze & Aluminum Co., Bronze Rd., Warren, Ohio
Oakite Products, Inc. (Ad p 361)
19 Rector St., New York 6, N.Y.
Oakland Foundry & Machine Co., 607-621 Woodward Ave., Rochester, Mich.
Oatey, L.R. Co., 10230 Berea Rd., Cleveland 2, Ohio
Octagon Process, Inc., 63 Bank St., Staten Island 1, N.Y.
Ohio Adhesives Corp., P.O. Box 466, New Philadelphia, Ohio
Ohio Carbon Co. (Ad p 322)
12508 Berea Rd., Cleveland 11, Ohio
Ohio Forge & Machine Corp., 3010 Woodhill Rd., Cleveland 4, Ohio
Ohio Metal Products Co., 35 N Bates St., Dayton 2, Ohio
Ohio Nut & Bolt Co., 33 1st Ave., Berea, Ohio
Ohio Nut & Washer Co., Box 66, Mingo Junction, Ohio
Ohio Precision Castings, Inc., 109 Webb St., Dayton 3, Ohio
Ohio Rubber Co., 301 Ben Hur Ave., Willoughby, Ohio
Ohio Screw Products, Inc., 818 West St., Elyria, Ohio
Ohio Steel Foundry Co., 1075 James St., Springfield, Ohio
Oil City Iron Works, P.O. Drawer 615, Corsicana, Tex.
Olderman Mfg. Corp., P.O. Box 917, Bridgeport, Conn.
Olds Alloys Co., 4481 Mason St., South Gate, Calif.
Olean Electro Plating Co., 890 N 4th St., Olean, N.Y.
Olin Mathieson Chemical Corp., 460 Park Ave., New York 22, N.Y.
Metals Div. (Ad p 155)
400 Park Ave., New York 22, N.Y.
Packaging Div., 655 Madison Ave., New York 21, N.Y.
Olson Mfg. Co., 100 Prescott St., Worcester 5, Mass.
Olympic Steel Works, 151 Horton St., Seattle 4, Wash.
Omaha Steel Works, 609 S 48th St., Omaha 6, Neb.
Omni Products Corp., 460 4th Ave., New York 16, N.Y.
Omni-Metal Castings, Inc., 135 11th St., Brooklyn 15, N.Y.
Optical Coating Laboratory, Inc., 2789 Giffen Ave., Santa Rosa, Calif.
Oregon Brass Works, 1127 SE 10th Ave., Portland 14, Ore.
Oregon Metallurgical Corp., P.O. Box 484, Albany, Ore.
Ormand Mfg. Co., Inc., 3325 Hudson Ave., Union City, N.J.
Ostby & Barton Co., Flightex Fabrics, Inc., 148 W River St., Providence 4, R.I.
O'Sullivan Rubber Corp., Valley Pike St., Winchester, Va.
Plastics Div., P.O. Box 603, Winchester, Pa.
Ottawa Steel Products, Inc., 745 Woodlawn Ave., Grand Haven, Mich.
Overmyer Mould Co., Inc., N Main St., Winchester, Ind.
Owen Mfg., Inc., S State Street Rd., Litchfield, Ill.
Owen Pattern Foundry & Mfg. Co., Inc., 710 W 22nd St., Norfolk 10, Va.
Owens-Corning Fiberglas Corp., 608 Madison Ave., Toledo 3, Ohio
Owens-Illinois Glass Co., Toledo, Ohio
Closure & Plastics Div., P.O. Box 1035, Toledo 1, Ohio
Kimble Glass Co. Sub., P.O. Box 1035, Toledo 1, Ohio
Paper Products Div., P.O. Box 1035, Toledo 1, Ohio

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Pabst Engineering Equipment Co., Inc., 676 Pennsylvania Ave., Elizabeth 3, N.J.
Pacific Brass Foundry of San Francisco, 251 2nd St., San Francisco 5, Calif.
Pacific Coast Foil Co., 500 Sansome St., San Francisco, Calif.
Pacific Foundry Co., Ltd., 3100 19th St., San Francisco, Calif.
Pacific Molded Products Corp., 905 E 59th St., Los Angeles 1, Calif.
Pacific Screw Products Co., 930 Linden Ave., South San Francisco, Calif.
Pacific Sintered Metals Co., 7728 El Manor Ave., Los Angeles, Calif.
Pacific States Steel Corp., Niles, Calif.
Pacific Tube Co., 5710 Smithway St., Los Angeles 22, Calif.
Paeco Rubber Co., Inc., 225 W Lake St., Ravenna, Ohio
Page Belting Co., Concord, N.H.
Palmyra Foundry Co., Inc., Palmyra, N.J.
Palnut Co., Glen Rd., Mountainside, N.J.
Pan-American Metal Products Co., Inc., 401 NW 71st St., Miami 38, Fla.
Panther Chemical Corp., P.O. Box 711, Ft. Worth, Texas
Paragon Die Casting Co., 5851 W Dickens Ave., Chicago 39, Ill.
Paragon Spring Co., 4613-17 W Fulton St., Chicago 44, Ill.
Paramount Die Casting Co., St. Joseph, Mich.
Paramount Paint & Lacquer Co., 3411 E 15th St., Los Angeles 23, Calif.
Park Drop Forge Co., 777 E 79th St., Cleveland 3, Ohio
Parker, Charles Co., Hanover St., Meriden, Conn.
Parker Appliance Co., Rubber Products Div., 17325 Euclid Ave., Cleveland 12, Ohio
Parker & Harper Mfg. Co., 119 Dewey St., Worcester 10, Mass.
Parker Metal Goods Co., 85 Prescott St., Worcester, Mass.
Parker Paint Mfg. Corp., Locust & Poplar Sts., Valparaiso, Ind.
Parker Rust Proof Co., 2177 E Milwaukee, Detroit 11, Mich.
Parker, Stearns & Co., Inc., 300 Sheffield Ave., Brooklyn 7, N.Y.
Parker White Metal Co., 2153 McKinley Ave., Erie, Pa.
Parker-Hannifin Corp., Parker Seal Co. Div., 10567 W Jefferson Blvd., Culver City, Calif.
Parker-Street Castings Co., Broadway & Chaincraft Rd., Cleveland 25, Ohio
Parkwood Laminates, Inc., 24 Water St., Wakefield, Mass.
Patterson Foundry & Machine Co., 41 Henene St., East Liverpool, Ohio
Pattin Mfg. Co., Box 527, Marietta, Ohio

In contacting suppliers, please mention the Materials Selector Issue

Paulson, Thomas & Son, Inc., 450 Union St., Brooklyn 31, N.Y
Pawling Rubber Corp., Pawling, N.Y.
Payne, F.S. Co., 75 Richdale Ave., Cambridge 40, Mass.
Peasley Products, Inc., 993 Honeyspot Rd., Stratford, Conn.
Peck Spring Co., Whiting St., Plainville, Conn.
Pecora Inc., 300-400 W Sedgley Ave., Philadelphia 40, Pa.
Pee Wee Molding Corp., 1720 Atlantic Ave., Brooklyn 13, N.Y.
Peerless Alloy Co., 1445 Osage St., Denver 4, Colo.
Peerless Automatic Machine Co., 1970 W 77th St., Cleveland 2, Ohio
Peerless Industries, Inc., P.O. Box 318, Plymouth, Mich.
Peerless Products Industries, 812-14-16 N Pulaski Rd., Chicago 51, Ill.
Peerless Wire Goods Co., Inc., 2703 Ferry St., LaFayette, Ind.
Pelron Corp., 7847 W 47th St., Lyons, Ill.
Pelton Steel Casting Co., 148 W Dewey Pl., Milwaukee 7, Wis.
Pemco Corp., Eastern & Pemco Aves., Baltimore, Md.
Pemco Wheel Co., 1872 Ravine Rd., Kalamazoo, Mich.
Penberthy Instrument Co., 4301 6th Ave. S, Seattle 8, Wash.
Pencoyd Steel & Forge Corp., 3720-40 Main St., Philadelphia 27, Pa.
Peninsular Steel Co., P.O. Box 3853, Parkgrove Sta., Detroit 5, Mich.
Penn Brass & Copper Co., 3837 W 20th St., Erie, Pa.
Penn Engineering & Mfg. Corp., Box 311, Doylestown, Pa.
Penn Extrusion Corp., 3837 W 20th St., Erie, Pa.
Penn Fibre & Specialty Co., Inc., 2024 E Westmoreland St., Philadelphia 34, Pa.
Penn Metal Co., Inc., P.O. Box 1480, Parkersburg, W. Va.
Penn Metal Co., Inc., 40 Central St., Boston 9, Mass.
Penn Steel Castings Co., Front & Penn Sts., Chester, Pa.
Pennsalt Chemicals Corp., 3 Penn Center, Philadelphia 2, Pa.
Pennsylvania Engineering Corp., P.O. Box 311, New Castle 17, Pa.
Pennsylvania Fluorocarbon Co., Inc., 1115 N 38th St., Philadelphia 4, Pa.
Pennsylvania Malleable Iron Corp., 712 S Prince St., Lancaster, Pa.
Penrod, Floyd & Sons Tool & Engineering Corp., 1208 W 2nd St., Muncie, Ind.
Peoria Malleable Casting Co., 2800 N Adams St., Peoria 1, Ill.
Peoria Plastic Co., East Peoria, Ill.
Pequonnock Foundry, Inc., 335 5th St., Bridgeport, Conn.
Pequot Wire Cloth Co., 35 Hoyt, Norwalk, Conn.
Perfecto Cast, 5660 Kearney Villa Rd., San Diego 11, Calif.
Perfex Plastics, Inc., 2632 S Dearborn, Chicago 16, Ill.

Perforating Industries, Inc. (Ad p 450)

606 Commerce Rd., Linden, N.J.

Perkins, Henry Co., Broad St., Bridgewater, Mass.
Permacel, U. S. Hwy. #1, New Brunswick, N.J.

Permali, Inc. (Ad p 431)

Box 718, Mount Pleasant, Pa.

Permold Co., 1250 W Liberty St., Medina, Ohio
Perrin, Edward C. Co., 3rd & Grant Sts., Camden 2, N.J.
Perry Fay Co., 200 Perry Court, Elyria, Ohio
Perry Plastics, Inc., 3409 W 14th St., Erie, Pa.
Perry-Austen Mfg. Co., 250 Parkinson Ave., Staten Island 5, N.Y.
Peterson, D. J. Co., Sheboygan, Wis.
Peterson Products Corp., 4848 N River Rd., Schiller Park, Ill.
Pettibone Mulliken Corp., 4700 W Division St., Chicago 51, Ill.
Pfaudler Co., West Ave. & Clark St., Rochester 3, N.Y.
Pfister Tubing Corp., 54 W Allendale Ave., Allendale, N.J.
Phelps Dodge Copper Products Corp., 300 Park Ave., New York 22, N.Y.
Phelps Dodge Refining Corp., 40 Wall St., New York, N.Y.
Pheoll Mfg. Co., Inc., 5700 W Roosevelt Rd., Chicago 50, Ill.
Philadelphia Asbestos Corp., 2010 N 10th St., Philadelphia 22, Pa.
Philadelphia Bronze & Brass Corp., 22nd & Masters Sts., Philadelphia 22, Pa.
Philadelphia Enameling Works, Inc., 254 N 13th St., Philadelphia 7, Pa.
Philadelphia Steel & Wire Corp., Penn St. & Belfield Ave., Philadelphia 44, Pa.
Philco Corp., Dexter Foundry Div., 501 N 8th St., Fairfield, Iowa
Phillips, F.C. Inc., 471 Washington St., Stoughton, Mass.
Phillips Chemical Co., Adams Bldg., Bartlesville, Okla.
Philrus Products Co., 135 Newark St., Newark 4, N.J.
Phoenix Die Casting Co., 21-23 Illinois St., Buffalo 3, N.Y.
Phoenix Iron & Steel Co., Front & Dock Sts., Harrisburg, Pa.
Phoenix Mfg. Co., Industry Ave., Joliet, Ill.
Phoenix Products Co., 4715 N 27th St., Milwaukee 9, Wis.
Picco, Inc., 1729 N Chico Ave., El Monte, Calif.
Pierce, F.O. Co., 2-33 50th Ave., Long Island City 1, N.Y.
Pierce Industries, Inc. of Ohio, S.T.D. Div., 1250 Asbestos Ave., Alliance, Ohio
Pierce & Stevens Chemical Corp., 710 Ohio St., Buffalo, N.Y.
Pioneer Aluminum Inc., 5251 W Imperial Blvd., Los Angeles 45, Calif.
Pioneer Stamped Products Co., P.O. Box 185, Roselawn Sta., Rochester 18, N.Y.
Piper Tool Co., Inc., 15930 Common Rd., Roseville, Mich.
Pittsburgh Corning Corp., 1 Gateway Center, Pittsburgh 22, Pa.
Pittsburgh Die & Casting Co., 7503 Ardmore St., Pittsburgh 18, Pa.
Pittsburgh Forgings Co., 919 Amur St., Jackson, Mich.
Pittsburgh Forgings Co., Thorn St., Coraopolis, Pa.
Pittsburgh Foundry & Machine Co., 36th St., Pittsburgh 1, Pa.
Pittsburgh Plate Glass Co., 632 Ft. Duquesne Blvd., Pittsburgh 22, Pa.

Fiber Glass Div. (Ad p 311)

1 Gateway Center, Pittsburgh 22, Pa.

Forbes Finishes Div., 3800 W 143rd St., Cleveland, Ohio
Pittsburgh Smelting & Refining Co., 100 W Ellzabeth St., Pittsburgh 7, Pa.
Pittsburgh Steel Co., P.O. Box 118, Pittsburgh 19, Pa.
Thomas Strip Div., Grant Bldg., Pittsburgh 30, Pa.
Pittsburgh Steel Foundry Corp., P.O. Box 986, Pittsburgh 30, Pa.
Fort Pitt Steel Casting Div., 25th St., McKeesport, Pa.
Pittsburgh Tool Steel Wire Co., Monaca, Pa.
Pittsburgh Tube Co., 212 Wood St., Pittsburgh 22, Pa.
Plast-Ad Mfg. Co., 222 N Michigan St., South Bend 1, Ind.
Plastex Co., 3232 Cleveland Ave., Columbus 24, Ohio
Plastic Engineering, Inc., 8506 Lake Ave., Cleveland 2, Ohio
Plastic Masters, Inc., New Buffalo, Mich.
Plastic Materials, Inc., New South Rd., Hicksville, N.Y.
Plastic Packaging Co., 2025 W Charleston St., Chicago 47, Ill.
Plastic Pipe & Tube Corp., 224 S Mipas St., Santa Barbara, Calif.
Plastic Process Co., Inc., 10400 Aviation Blvd., Los Angeles 45, Calif.
Plastic Products Corp., 24001 Aurrora Rd., Bedford Heights, Ohio.
Plasticrafters, Inc., 1829 S 55th Ave., Cicero 50, Ill.

Plastics Engineering Co. (Ad p 270)

1607 Geele Ave., Sheboygan, Wis.

Plastiglide Mfg. Corp., 1757 Stanford St., Santa Monica, Calif.
Pipco International Corp., 1731 Stanford St., Santa Monica, Calif.
Plastic Compounding Corp., 3122 Nebraska Ave., Santa Monica, Calif.
Plax Corp., Box 1019, Hartford, Conn.
Plumb Chemical Corp., 4837 James St., Philadelphia 37, Pa.
Plume & Atwood Mfg. Co., Thomaston, Conn.
Plymouth Cordage Co., Plymouth, Mass.
Plymouth Industrial Products, Inc., 503 Indiana Ave., Sheboygan, Wis.
Pohlman, R.L. Co., 6730 Olive St. Rd., St. Louis 5, Mo.
Pohlman Foundry Co., Inc., 205 Baitz Ave., Buffalo 6, N.Y.
Polacoat, Inc., 9752 Conklin Rd., Cincinnati 42, Ohio
Polar Ware Co., Lakeshore Rd., Sheboygan, Wis.
Pollock, Robert Co., 123 S Maryland Ave., Glendale, Calif.
Polo Plastics Co., 1718 N 1st St., Milwaukee 12, Wis.
Poly Resins, 11661 Wicks St., Sun Valley, Calif.
Polycast Corp., 69 Southfield Ave., Stamford, Conn.
Polyform Plastics Corp., 24 University Pl., New York 3, N.Y.
Polygon Plastic Co., Walkerton, Ind.
Poly-Kote, Inc., 82 Chestnut St., North Attleboro, Mass.
Polymer Chemical Co., 5920 Carthage Ave., Cincinnati 12, Ohio
Polymer Corp., 2120 Fairmont Ave., Reading, Pa.

Polymer Corp. of Pennsylvania Sub. (Ad p 230)

2140 Fairmont Ave., Reading, Pa.

Whirlclad Div., 125 N 4th St., Reading, Pa.
Polymer Industries Inc., Springdale, Conn.
Polyphase Machine Co., 43-22 50th St., Woodside 77, N.Y.
Polyplastic Products, Inc., 24th Ave., Paterson, N.J.
Polytron Corp., 1175 S 10th St., Richmond 4, Calif.
Poor & Co., 80 E Jackson Blvd., Chicago, Ill.
Canton Forge & Axle Works, 2025 Dueber Ave., SW, Canton 6, Ohio
Promat Div., 851 S Market St., Waukegan, Ill.
Porcelain Enamel Finishers, 3221 W 30th St., Chicago 23, Ill.
Porcelain Products, Inc., 224 N Patterson, Carey, Ohio
Portable Electric Tools, Inc., Admiral Die Castings Div., 250 W 83rd St., Chicago 20, Ill.
Porter, H.K. Inc., 74 Foley, Somerville 43, Mass.
Porter, H.K. Co., Inc., Alcoa Bldg., Pittsburgh 19, Pa.
Connors Steel Div., 5000 Powell Ave., Birmingham 6, Ala.
Forge & Fittings Div., 3270 E 79th St., Cleveland 4, Ohio
National Electric Div., Porter Bldg., Pittsburgh 19, Pa.
Refractories Div., Porter Bldg., Pittsburgh 19, Pa.

Riverside-Alloy Metal Div. (Ad p 160)

1 Pavillion Ave., Riverside, N.J.

Thermoid Div., Tacony & Comly Sts., Philadelphia 24, Pa.
Vulcan-Kidd Steel Div., Aliquippa, Pa.
Porter, William Co., 1007 Santa Fe Ave., Los Angeles 21, Calif.
Portland Co., 58 Fore St., Portland, Me.
Portland Iron Works, 1335 NW Northrup St., Portland 9, Ore.
Posey Iron Works, Inc., 580 S Prince St., Lancaster, Pa.
Potts, C. & G. & Co., 816 Washington Ave., Indianapolis, Ind.
Powder Metals Products Co., 500 St. Marys St., St. Marys, Pa.
Powdercraft Corp., 746 Hayne St., Spartanburg, S. C.
Powell Pressed Steel Co., Hubbard, Ohio
Pratt & Lambert, Inc., 75 Tonawanda St., Buffalo 7, N.Y.
Precision Castparts Corp., 4600 SE Harney Dr., Portland 6, Ore.

Precision Extrusions, Inc. (Ad p 458)

132 S Addison St., Bensenville, Ill.

Precision Founders, Inc., 414 Hester St., San Leandro, Calif.
Precision Machine Co., 1110 E 22nd St., Indianapolis 2, Ind.
Precision Metal Products Co., P.O. Box 129, Ellwood City, Pa.
Precision Metal Spinning Co., 9861 Dixie Hwy., Clarkston, Mich.
Precision Metalsmiths, Inc., 1081 E 200 St., Cleveland 17, Ohio
Precision Paper Tube Co., 2035 W Charleston St., Chicago 47, Ill.
Precision Piece Parts, Inc., 712 S Logan St., Mishawaka, Ind.
Precision Plastics Co., 4655 Stenton Ave., Philadelphia 44, Pa.
Precision Rubber Products Corp., 3110 Oakridge Dr., Dayton 7, Ohio
Precision Screw Products Co., Inc., 4764 Valley Blvd., Los Angeles 32, Calif.
Precision Tube Co., Inc., Church Rd. & Wissahickon Ave., North Wales, Pa.
Premier Metal Works, Inc., 1614 S Clinton St., Chicago 16, Ill.
Premier Thermo Plastics Co., Jeffersontown, Ky.
Prescott Co., 1610 15th St., Menominee, Mich.
Presmet Corp., 112 Harding St., Worcester 4, Mass.
Pressed Steel Co., Wilkes Barre, Pa.
Pressed Steel Tank Co., 1493 S 66th St., Milwaukee 14, Wis.
Pressure Castings, Inc., 21500 St. Clair Ave., Cleveland 19, Ohio
Presswork, Inc., 9100 Roselawn Ave., Detroit 4, Mich.
Presto Plastic Products Co., Inc., 5410 Ave. U, Brooklyn 34, N.Y.
Prestole Corp., 1345 Miami St., Toledo 5, Ohio
Prince Rubber & Plastics Co., Inc., 1675 Niagara St., Buffalo 7, N.Y.
Production Die Casting Co., P.O. Box 9456, Houston 11, Tex.
Progressive Service Co., 2745 Locust St., St. Louis 3, Mo.
Protective Treatments, Inc., 420 Dellrose Ave., Dayton, Ohio
Puget Sound Plywood, Inc., 230 E. F St., Tacoma 2, Wash.
Purdy, A. R. Co., Inc., Page Ave. & Orient Way, Lyndhurst, N.J.
Pure Carbon Co., Inc., 441 Hall Ave., St. Marys, Pa.

Puritan Co., Inc., Beach & Lyell Aves., Rochester, N.Y.
Pusey & Jones Corp., Front & Poplar Sts., Wilmington 9, Del.
Pyramid Industries, Inc., 1422 Irwin Dr., Erie, Pa.
Pyramid Mouldings, Inc., 5353 W Armstrong Ave., Chicago 46, Ill.
Pyramid Plastics, Inc., 556 W Polk St., Chicago 7, Ill.
Pyramid Products Co., Inc. (Ad p 458)
3967 E 93rd St., Cleveland 5, Ohio
Pyro Plastics Corp., Pyro Park, Union, N.J.
Pyron Corp. (Ad p 432)
Box E, LaSalle Sta., Niagara Falls, N.Y.
Pyrosil, Inc., P.O. Box 206, Cuyahoga Falls, Ohio

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Quaker Alloy Casting Co., Myerstown, Pa.
Quaker City Felt Co., 1734-36 Ludlow St., Philadelphia, Pa.
Quaker State Metals Co., P.O. Box 1167, Lancaster, Pa.
Quality Aluminum Casting Co., 1242 Lincoln Ave., Waukesha, Wis.
Quality Electric Steel Castings, Inc., P.O. Box 9382, Houston 11, Tex.
Queen Products Co., Inc., 13th & Rowan Sts., Louisville 3, Ky.
Quelcor, Inc., Front & Broomall Sts., Chester, Pa.
Quincy Steel Casting Co., 30 Fayette St., North Quincy 71, Mass.
Quinn-Berry Corp., 2609 W 12th St., Erie, Pa.

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REF Mfg. Corp., 391 Jericho Tpk., Mineola, N.Y.
Racine Screw Co., 1501 Clark St., Racine, Wis.
Radiant Color Co., 830 Isabella St., Oakland 7, Calif.
Radiation Applications, Inc., 42-30 24th St., Long Island City 1, N.Y.
Raffi and Swanson, Inc., 100 Eames St., Wilmington, Mass.
Rainier Metal Products Co., 2412 W 71st St., Chicago 29, Ill.
Rand Rubber Co., 397 Sumner Ave., Brooklyn 16, N.Y.
Randolph Products Co., 18 12th St., Carlstadt, N.J.
Rangers Die Casting Co., 10828 S Alameda St., Lynwood, Calif.
Rankin Forge Co., Rankin, Pa.
Rasco-Veeder Co., 1600 S Dearborn St., Chicago 16, Ill.
Rathbone Corp., Park St., Palmer, Mass.
Rausch Mfg. Co., Inc., 750 Pelham Blvd., St. Paul 14, Minn.
Ravenswood Machine Corp., 3325 N Knox Ave., Chicago 41, Ill.
Raybestos-Manhattan, Inc., 61 Willett St., Passaic, N.J.
Adhesives Div. (Ad p 492)
P.O. Box 1021, Bridgeport 2, Conn.
Plastic Products Div. (Ad p 268)
Manheim, Pa.
Raybestos Div., P.O. Box 1021, Bridgeport 2, Conn.
Reactive Metals, Inc., 980 Warren Ave., Niles, Ohio
Reade Mfg. Co., Inc., 135 Hoboken Ave., Jersey City 2, N.J.
Reading Tube Corp., Empire State Bldg., 350 5th Ave., New York, N.Y.
Red Devil Mfg. Co., 1412 N Ogden Ave., Chicago 10, Ill.
Redmer Air Devices, Box 247, Guntersville, Ala.
Reduction and Refining Co., Kenilworth, N.J.
Reed Plastics Corp., 116 Gold St., Worcester 8, Mass.
Reed & Prince Mfg. Co., 1 Duncan Ave., Worcester 1, Mass.
Reese Metal Products Corp., 537 Howard Ave., Lancaster, Pa.
Reeves Bros., Inc., Vulcan Rubber Products Div. (Ad p 318)
1071 Ave. of Americas, New York, N.Y.
Refinery Castings Co., P.O. Box 5085, Dallas 22, Tex.
Refin Co., 5660 Kearney Villa Rd., San Diego 11, Calif.
Refractory & Insulation Corp., 120 Wall St., New York 5, N.Y.
Refractory Specialties Co., 2200 Washington Ave., Philadelphia 46, Pa.
Regal Plastic Co., 2800 E 14th St., Kansas City 27, Mo.
Regal Ware, Inc., Kewashum, Wis.
Reichert Float & Mfg. Co. (Ad p 464)
2242 Smead Ave., Toledo 6, Ohio
Reichhold Chemicals, Inc., 525 N Broadway, White Plains, N.Y.
Reinhold Engineering & Plastics Co., 12827 E Imperial Hwy., Norwalk, Calif.
Reliable Screw Machine Products, 4433 W Rice St., Chicago 51, Ill.
Reliable Spring & Wire Forms Co., 3167 Fulton Rd., Cleveland 9, Ohio
Reliance Foundry Co., 500-526 E Front St., Cincinnati 2, Ohio
Reliance Plastic & Chemical Corp., 110 Kearney St., Paterson 2, N.J.
Reliance Steel Castings Co., 2818 Smallman St., Pittsburgh 22, Pa.
Remler Co., Ltd., 2101 Bryant St., San Francisco 10, Calif.
Ren Plastics, Inc., 5422 S Cedar Rd., Lansing 17, Mich.
Rensselaer Valve Co., Cohoes, N.Y.
Replac Corp., 2130 St. Clair Ave., Cleveland 17, Ohio
Republic Die Casting Co., 611 Talcott Ave. St. Louis 7, Mo.
Republic Foil, Inc., 55 Triangle St., Danbury, Conn.
Republic Lead Equipment Co., 7930 Jones Rd., Cleveland 5, Ohio
Republic Metals Co., Inc., 273 Green, Brooklyn 22, N.Y.
Republic Steel Corp. (Ad pp 84-85)
Republic Bldg., Cleveland 1, Ohio
Steel & Tubes Div., 224 E 131st St., Cleveland 8, Ohio
Resistoflex Corp., Woodland Rd., Roseland, N.J.
Resolite Corp., P.O. Box 366, Zelienople, Pa.
Revere Copper & Brass, Inc., 230 Park Ave., New York 17, N.Y.
Foil Div., 196 Diamond St., Brooklyn 22, N.Y.
Rome Mfg. Div., Mill St., Rome, N.Y.
Rex Products Co., 1918 E 55th St., Cleveland 3, Ohio
Reynolds Aluminum Supply Co., 573 W Peachtree St., NE, Atlanta 3, Ga.
Reynolds Chemical Products Co., 1200 N Main St., Ann Arbor, Mich.
Reynolds Metals Co., P.O. Box 2346-ZA, Richmond, Va.
Foil Div., Reynolds Metals Bldg., Richmond 18, Va.
Rezolin, Inc., 1051 18th St., Santa Monica, Calif.
Rhoads, J.E. & Sons, 2100 W 11th St., Wilmington, Del.
Rhode Island Tool Co. (Ad p 450)
148 W River St., Providence 1, R.I.
Richardson Co., 2737 Lake St., Melrose Park, Ill.
Richmond Foundry & Mfg. Co., Inc., 1300 Hermitage Rd., Richmond 20, Va.
Richmond Mfg. Co., 312 N York St., Houston 3, Tex.
Richmond Mica Corp., 900 Jefferson Ave., Newport News, Va.
Ridge Foundry, 1554 Doolittle Dr., San Leandro, Calif.
Riegel Paper Co., 260 Madison Ave., New York 16, N.Y.
Rigidized Metals Corp., 658 Ohio St., Buffalo 3, N.Y.
Rinshed-Mason Co., Milford at Epworth, Detroit, Mich.
River Smelting & Refining Co., 4195 Bradley Rd., Cleveland 1, Ohio
Riverside Foundry Co., N Front St., Wrightsville, Pa.
Riverside Foundry & Galvanizing Co., 508 Harrison St., Kalamazoo, Mich.
Riverside Plastics Corp., 220 Miller Rd., Hicksville, N.Y.
Roberts Toledo Rubber Co., 4143 Monroe St., Toledo 13, Ohio
Robertson, H.H. Co., 2400 Farmer Bank Bldg., Pittsburgh, Pa.
Robertson Steel & Iron Co., 72 Elm St., Cincinnati 2, Ohio
Rochester Novelty Works, Inc., 485 Hague St., Rochester 6, N.Y.
Rockford Bolt & Steel Co., 126 Mill St., Rockford, Ill.
Rockwell Engineering Co., 13500 S Western Ave., Blue Island, Ill.
Rockwell Mfg. Co., LFM Mfg. Co., Inc. Sub., Atchison, Kan.
Rockwell - Standard Corp., Stamping Div. (Ad p 458)
1008 Oswego St., Utica 1, N.Y.
Roddis Plywood Corp., Marshfield, Wis.
Rode, Inc., R5 Green St., Woburn, Mass.
Rodney Hunt Machine Co., 46 Mill St., Orange, Mass.
Rodney Metals, Inc., 1357 Rodney French Blvd., New Bedford, Mass.
Rogers Corp. (Ad p 261)
Rogers, Conn.
Rogers, V.F. Plastic Molding, 4320 Fox St., Denver 16, Colo.
Rohm & Haas Co., Washington Square, Philadelphia 5, Pa.
Rohnco, Inc., 116 Limestone, Bellevue, Peoria 5, Ill.
Rohr Aircraft Corp., Foot of "H" St., Chula Vista, Calif.
Rolinco, Inc., 116 Limestone, Bellevue, Peoria 5, Ill.
Roll Coater, Inc., Box 67, Pendleton, Ind.
Roll Formed Products Co., 3762 Oakwood Ave., Youngstown, Ohio
Rolle Mfg. Corp., 3rd St. & Cannon Ave., Lansdale, Pa.
Rolled Alloys, Inc., 5309 Concord, Detroit 11, Mich.
Roller Reinforced Plastics, W 47th St., Box 192, Ashtabula, Ohio
Rolock, Inc., 1350 Kings Hwy., Fairfield, Conn.
Romar Plastics, Inc., 1311 E Main St., St. Charles, Ill.
Rome Strip Steel Co., Inc., 530 Henry St., Rome, N.Y.
Rome Turney Radiator Co., Rome, N.Y.
Rosan, Inc., 2901 W Coast Hwy., Newport Beach, Calif.
Rosco Laboratories, 29 Moore St., Brooklyn 6, N.Y.
Rose Iron Works, 1539 E 43rd St., Cleveland 3, Ohio
Rosedale Foundry & Machine Co., 1731 Prebel Ave., Pittsburgh 33, Pa.
Ross & Roberts, Inc., 1299 W Broad St., Stratford, Conn.
Ross-Meehan Foundries, 1601 Carter St., Chattanooga 1, Tenn.
Rostone Corp., Rd. 52 S, Lafayette, Ind.
Roth Rubber Co., 1854 S 54th St., Chicago 50, Ill.
Roth Steel Products Co., 1335 E 171st St., Cleveland 10, Ohio
Rotometals, 980 Harrison St., San Francisco 7, Calif.
Rowland Products, Inc., Fairview Lane, Kensington, Conn.
Royce Aluminum Corp., 704 W Water St., Taunton, Mass.
Rubber & Asbestos Corp., 225 Belleville Ave., Bloomfield, N.J.
Rubber Corp. of America, New South Rd., Hicksville, L.I., N.Y.
Rubber & Plastics Compound Co., Inc., 10 Rockefeller Plaza, New York 20, N.Y.
Ruberoid Co., 500 5th Ave., New York 36, N.Y.
Funkhouser Mills Div., P.O. Box 569, Hagerstown, Md.
Ruby Chemical Co., 68-70 McDowell St., Columbus 16, Ohio
Rupert Diecasting Co., 1655 Cleveland Ave., Kansas City 27, Mo.
Russell, Burdsall & Ward Bolt & Nut Co. (Ad p 501)
Midland Ave., Port Chester, N.Y.
Russell Mfg. Co., 400 E Main St., Middletown, Conn.
Russell Reinforced Plastics Corp., 521 W Hoffman Ave., Lindenhurst, N.Y.
Rust-Oleum Corp., 2425 Oakton St., Evanstown, Ill.
Rustproofing & Metal Finishing Corp., 75 Commercial Ave., Cambridge 42, Mass.
Ryerson, Joseph T. & Son, Inc., 16th & Rockwell Sts., Chicago 8, Ill.

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S & S Mfg. Co., 6139 Adams St., West New York, N.J.
Sager Metal Strip Co., 3649 S Racine, Chicago 9, Ill.
Saginaw Bay Industries, Inc., 242 N Water St., Bay City, Mich.
Saginaw Bearing Co., 821 S Water St., Saginaw, Mich.
St. Clair Rubber Co., 440 E Jefferson Ave., Detroit 26, Mich.
St. Eloi Corp., Box 507, Newtown Station, Cincinnati 44, Ohio
St. Joseph Lead Co., 250 Park Ave., New York 17, N.Y.
St. Louis Diecasting Corp., 4528 Oleatha Ave., St. Louis 16, Mo.
St. Louis Malleable Casting Co., 7701 N Conduit Ave., St. Louis, Mo.
St. Louis Steel Casting, Inc., 100 Mott St., St. Louis 15, Mo.
St. Marys Carbon Co., State Rd., St. Marys, Pa.
St. Marys Foundry Co., P.O. Box 248, St. Marys, Ohio
St. Pierre Chain Corp., 50 Frank St., Worcester 4, Mass.
St. Regis Paper Co., 150 E 42nd St., New York, N.Y.
Cambridge-Panelyte Molded Plastics Co. Div., Cambridge, Ohio
Chester Packaging Div., 684 Nepperhan Ave., Yonkers, N.Y.
Panelyte Div. (Ad p 250)
Enterprise Ave., Trenton 8, N.J.
Sall Bros. Co., 2300 Kishwaukee St., Rockford, Ill.
Sall, George Metals Co., Inc., 2255 E Butler St., Philadelphia 37, Pa.
San Francisco Galvanizing Works, 1180 Harrison St., San Francisco 3, Calif.

In contacting suppliers, please mention the Materials Selector Issue

San Francisco Iron Foundry, 260 Townsend St., San Francisco 7, Calif.

Sandusky Foundry & Machine Co. (Ad p 427)
W Market St., Sandusky, Ohio

Sandvik Steel, Inc. (Ad p 83)
1702 Nevins Rd., Fair Lawn, N.J.

Sandy Hill Iron & Brass Works, 27 Allen St., Hudson Falls, N.Y.

Sanford Plastics Corp., 521 Fifth Ave., New York 17, N.Y.

Sanford Process Co., Inc., 6920 S Central Ave., Los Angeles 1, Calif.

Santay Corp., 351 N Crawford Ave., Chicago 24, Ill.

Saramar Aluminum Co., 4021 Mahoning Ave., Youngstown 1, Ohio

Saran Protective Coatings Co., 2415 Burdette Ave., Detroit 20, Mich.

Sargent & Greenleaf, Inc., 24 Seneca Ave., Rochester 21, N.Y.

Sauereisen Cements Co., 1045 N Canal St., Pittsburgh 15, Pa.

Saunders, Alexander & Co., Inc., 195 Bedford St., New York 14, N.Y.

Savannah Machine and Foundry Co., Foundry Div., P.O. Box 590, Savannah, Ga.

Sawbrook Steel Castings Co., Shepherd & McWhorter Sts., Lockland, Cincinnati 15, Ohio

Sawhill Tubular Products, Inc., P.O. Box 11, Sharon, Pa.

Saxonburg Ceramics, Saxonburg, Pa.

Scaife Co., Anne St., Oakmont, Pa.

Schachner Leather & Belting Co., Charlotte Leather Belting Co. Div., P.O. Box 3205, Charlotte 3, N.C.

Schaefer-Goodnow Foundries, Inc., 2 36th St., Pittsburgh 1, Pa.

Schaefer-Hausner Corp., 527 Lexington Ave., New York 17, N.Y.

Schenectady Varnish Co., Inc., Congress St. & 9th Ave., Schenectady 3, N.Y.

Schilling Bronze Co., 202-216 E North St., Rome 2, N.Y.

Schlueter Mfg. Co., 4616 N Broadway, St. Louis 7, Mo.

Schmeller Aluminum Foundry Co., 3300 E 87th St., Cleveland 27, Ohio

Schneider, Bowman Co., Inc., 1612 Van Dyke St., Philadelphia 24, Pa.

Schultz Die Casting Co., 1810 Clinton St., Toledo 7, Ohio

Schumann, I. & Co., 4391 Bradley Rd., P.O. Box 2219, Cleveland 9, Ohio

Schwab Plastics Corp., 17310 Northlawn, Detroit, Mich.

Schwartz Chemical Co., Inc., 50-01 2nd St., Long Island City, N.Y.

Schwarzkopf Development Corp., 595 Madison Ave., New York 22, N.Y.

Scott Paper Co., Foam Div., Delaware & Broomall, Chester, Pa.

Scottdale Ozone Co., Crescent St., Scottdale, Pa.

Scovill Mfg. Co., Mill Products Div. (Ad pp 169-170)
99 Mill St., Waterbury 20, Conn.

Scranton Plastic Laminating Corp., 3216-18 Pittston Ave., Scranton 5, Pa.

Scudder, E.J. Foundry & Machine Co. Canal & Pearl Sts., Trenton 9, N.J.

Scullin Steel Co., 6700 Manchester Ave., St. Louis 10, Mo.

Seal-Peel, Inc., 755 Stephenson Hwy., Royal Oak 3, Mich.

Sealube Co., 14 Valley St., Wakefield, Mass.

Sealview Plastics, Inc., 1010 Ford St., West Conshohocken, Pa.

Seaman Products, 13001 Bradley Ave., Sylmar, Calif.

Seamless Rubber Co., 253 Hallock Ave., New Haven 3, Conn.

Seaporcel Metals, Inc., 28-20 Borden Ave., Long Island City, N.Y.

Seattle Boiler Works, Inc., 5237 E Marginal Way, Seattle, Wash.

Security Cos., 20096 James Couzens, Detroit 38, Mich.

Security Sash & Screen Co., 385 Midland, Detroit, Mich.

Seiberling Rubber Co., Plastics Div., Newcomerstown, Ohio

Selma Foundry & Machine Co., P.O. Box 662, Selma, Ala.

Sel-Rex Corp. (Ad p 356)
75 River Rd., Nutley 10, N.J.

Seltzer, George H. & Co., Ridley & B & O RR, P.O. Box 66, Folsom, Pa.

Semon Bache & Co., 636 Greenwich St., New York 14, N.Y.

Seneca Wire & Mfg. Co., Fostoria, Ohio

Sequoia Metalcraft Co., Inc., 1001 Washington St., San Carlos, Calif.

Serrick Corp., Defiance, Ohio
- Acme Machine Products Div., 1300 Batavia St., Muncie, Ind.
- John Lees Div., 1300 Batavia St., Muncie, Ind.
- Screw Machine Products Div., 731-22 Perry, Defiance, Ohio

Service Steel Co., 1435 Franklin St., Detroit 7, Mich.

Serwell Products Co., 6541 Euclid Ave., Cleveland 3, Ohio

Set Screw & Mfg. Co. (Ad p 496)
149 Main St., Bartlett, Ill.

Sewell Mfg. Co., 1019 E 10 Mile Rd., Hazel Park, Mich.

Seymour Mfg. Co. (Ad p 178)
15 Franklin St., Seymour, Conn.

Shakopee Foundry Co., Shakopee, Minn.

Shamban, W.S. & Co., 11617 W Jefferson Blvd., Culver City, Calif.

Shank Metal Products Co., 347 Madison Ave., New York 17, N.Y.

Sharon Steel Corp., Sharon, Pa.
- Brainard Steel Div., Griswold St., Warren, Ohio

Sharpsville Steel Fabricators, Inc., 6th & Main Sts., Sharpsville, Pa.

Shaw Insulator Co., 160 Colt St., Irvington 11, N.J.

Shawinigan Resins Corp., 644 Monsanto Ave., Springfield 1, Mass.

Shaw-Kendall Engineering Co., 120 S Superior St., P.O. Box 1736, Toledo 3, Ohio

Sheffield Foundry Co., 2070 Clybourn Ave., Chicago 14, Ill.

Sheffield Plastics, Inc., Salisbury Rd., Sheffield, Mass.

Shelby Instrument Co., 1701 Magnolia Ave., Long Beach, Calif.

Shelby Mfg. Co., E Russel Rd., Sidney, Ohio

Sheldon, M.L. & Co., Inc., 350 Lexington Ave., New York 16, N.Y.

Shell Chemical Co., 50 W 50th St., New York 20, N.Y.

Sheller Mfg. Corp., 8-159 General Motors Bldg., Detroit 2, Mich.
- Dryden Rubber Div., 1014 S Kildare Ave., Chicago 24, Ill.

Shenango Furnace Co., Centrifugally Cast Products Div. (Ad p 422)
Dover, Ohio

Shenango Refractories, P.O. Box 120, New Castle, Pa.

Sherman & Reilly, Inc., 1st & Broad Sts., Chattanooga, Tenn.

Sherwatt Equipment & Mfg. Co., Inc., 47 Murray St., New York 7, N.Y.

Sherwin-Williams Co., 101 Prospect Ave., NW, Cleveland 1, Ohio

Shieldalloy Corp., West Blvd., New Field, N.J.

Shingle Leather Co., 1300 Walnut St., Camden 3, N.J.

Shoe Form Co., Inc., De Witt Plastics Div., Aurelius Ave., Auburn, N.Y.

Shriver, T. & Co., Inc., 890 Hamilton St., Harrison, N.J.

Shull Bros. Glass Co., 509 N 6th St., Millville, N.J.

Shur-Lok Corp., 879 S East St., Anaheim, Calif.

Sibley Machine & Foundry Corp., 206 E Tutt St., South Bend 23, Ind.

Sierra Electric Corp., 15100 S Figueroa St., Gardena, Calif.

Sierra Engineering Co., 123 E Montecito, Sierra Madre, Calif.

Sifco Metachemical, Inc., 935 E 63rd St., Cleveland 3, Ohio

Sillcocks Miller Co., 10 W Parker Ave., Maplewood, N.J.

Simmons Fastener Corp. (Ad p 497)
N Broadway, Albany 1, N.Y.

Simon Products Co., 3211 W Grand St., Chicago 51, Ill.

Simonds Saw and Steel Co., 470 Main St., Fitchburg, Mass.

Simonsen Metal Products Co., 4444 W Chicago, Chicago 51, Ill.

Simpson Timber Co., 1010 White Bldg., Seattle, Wash.

Sinclair Co., 60 Appleton St., Holyoke, Mass.

Sinko Mfg. & Tool Co., 7310 W Wilson Ave., Chicago 31, Ill.

Sintered Metals, Inc., 3390 Washington St., Jamaica Plain 30, Mass.

Sioux City Foundry & Boiler Co., E 8th & Division Sts., Sioux City 2, Iowa

Sipe Metals Corp., 1720 N Elston Ave., Chicago 22, Ill.

Sivyer Steel Casting Co., 43rd & Mitchell Ave., Milwaukee 14, Wis.

Skookum Co., Inc., 8504 W Crawford St., Portland 3, Ore.

Skyline Industries, Titusville 1, Pa.

Small Tube Products, Inc., Main St., Waterbury, Conn.

Smith, A.O. Corp., 3533 N 27th St., Milwaukee 1, Wis.

Smith, A.P. Mfg. Co., 500 N Arlington Ave., East Orange, N.J.

Smith, N.J. Bolt Co., P.O. Box 7398, Houston 8, Tex.

Smith Chemical & Color Co., Inc., 55 John St., Brooklyn 1, N.Y.

Smith & Winchester Mfg. Co., South Windham, Conn.

Smith-Armstrong Forge, Inc., 1209 Marquette Rd., Cleveland 14, Ohio

Smithers Tool & Machine Products, Inc., 64 S Broadway, Red Hook, N.Y.

Smith-Moon Steel Co., Inc., Courier Bldg., Winfield, Kan.

Smith-Victor Corp., Griffith, Ind.

Smoot-Holman Co., 321 N Eucalyptus Ave., Inglewood, Calif.

Snyder Mfg. Co., Inc., 1458 5th St. NW, New Philadelphia, Ohio

Snyder, M.L. & Son, Inc., Jasper & York Sts., Philadelphia 15, Pa.

Solar Aircraft Co., 2200 Pacific Hwy., San Diego 12, Calif.

Solar Steel Corp., Union Commerce Bldg., Cleveland, Ohio

Solon Foundry, Inc., 6370 SOM Center Rd., Solon, Ohio

Somers Brass Co., Inc. (Ad p 162)
94 Baldwin Ave., Waterbury 20, Conn.

Somerset Foundry & Machine Co., 809-831 Edgewood Ave., Somerset, Pa.

Sommer Metalcraft Corp., 315 Poston Dr., Crawfordsville, Ind.

Sonken-Galamba Corp., 2nd & Riverview, Kansas City 18, Kan.

Sorbo-Cast Corp., New Brunswick, N.J.

Sorbo-Mat Process Engineers, 106 S Hanley St., St. Louis 5, Mo.

South Chester Corp., Southco Div., Lester, Pa.

South River Metal Products Co., Inc., 377 Turnpike, South River, N.J.

Southern Adhesives Corp., 1501 W Moore St., Richmond, Va.

Southern Aluminum Finishing Co., Inc., 1581 Huber St., NW, Atlanta 18, Ga.

Southern Asbestos Co., 1000 Seaboard Rd., Charlotte, N.C.

Southern Belting & Transmission Co., P.O. Box 4296, Atlanta 2, Ga.

Southern Car & Mfg. Co., Inc., 1831 29th Ave. N, Birmingham, Ala.

Southern Extrusions, Inc., N Washington St., Magnolia, Ark.

Southern Fabricating Co., Inc., 818 20th St., Sheffield, Ala.

Southern Galvanizing Co., 1620 Bush St., Baltimore 30, Md.

Southern Metal Products Co., 4444 N Miro St., New Orleans 17, La.

Southern Plastics Co., 408 Pendelton St., Columbia, S.C.

Southern Screw Co., P.O. Box 1360, Statesville, N.C.

Southwestern Plastic Pipe Co., P.O. Box 117, Mineral Wells, Tex.

Southwestern Porcelain Steel Corp., P.O. Box 607, Sand Springs, Okla.

Spaulding Fibre Co., Inc. (Ad p 255)
310 Wheeler St., Tonawanda, N.Y.

Special Screw Products Co., 100 Northfield Rd., Bedford, Ohio

Specialty Resins Co., 2801 Lynwood Rd., Lynwood, Calif.

Speer Carbon Co. (Ad p 318)
St. Marys, Pa.

Spencer Chemical Co., Dwight Bldg., 1004 Baltimore Ave., Kansas City 5, Mo.

Spencer Nahm Co., 765 1st Ave., San Leandro, Calif.

Spencer Rubber Co., Main & Chapel Sts., Manchester, Conn.

Spencer's Sons, I.S. Inc., 20 Fair St., Guilford, Conn.

Spincraft, Inc., 4122 W State St., Milwaukee 8, Wis.

Spiral-Glas Pipe Co., P.O. Box 1951, Old Bridge, N.J.

Sprayiat Corp., 1 Park Ave., New York 16, N.Y.

Spring City Foundry Co., Hall & Main Sts., Spring City, Pa.

Spring Packing Corp., 332 S Michigan Ave., Chicago 4, Ill.

Springer's Foundry Co., Inc., 201 S 1st St., Terre Haute, Ind.

Springfield Foundry Co., 295 Pasco Rd., Indian Orchard, Mass.

Spruce Pine Mica Co., Inc., P.O. Box 450, Spruce Pine, N.C.

Spuck Iron & Foundry Co., 3145 N 14th St., St. Louis 7, Mo.

Stacey Mfg. Co., Township Ave., & Big Four RR, Cincinnati 16, Ohio

Stackpole Carbon Co. (Ad p 320)
St. Marys, Pa.

Stainless Foundry & Engineering, Inc., 5132 N 35th St., Milwaukee 9, Wis.

Stainless Metals, Inc., 19-42 42nd St., Long Island City 1, N.Y.

Stalker Corp., 203 Woodside Ave., Essexville, Mich.

Stalwart Rubber Co., 160 Northfield Rd., Bedford, Ohio

Stamford Metal Specialty Co., Inc., 429 W Broadway, New York 12, N.Y.

Stamford Rolling Mills Co., Inc., Springdale, Conn.

Standard Asbestos Mfg. Co., 860 W Evergreen Ave., Chicago 22, Ill.

Standard Casting Corp., 4400 W Cermak Rd., Chicago 23, Ill.

Standard Felt Co., 29-115 S Palm Ave., Alhambra, Calif.

Standard Forge & Axle Co., Inc., P.O. Box 309, Montgomery 1, Ala.

Standard Foundry Co., Southgate & Armory Sts., Worcester 10, Mass.

Standard Insulation Co., Plastics Div., 74 Paterson Ave., East Rutherford, N.J.

Standard Locknut & Lockwasher Inc., 2250-56 Valley Ave., Indianapolis 18, Ind.

Standard Magnesium Corp., 7500 E 41st St., Tulsa, Okla.

Standard Metals Corp., 262 Broad St., North Attleboro Mass.
Standard Nut & Bolt Co., Abbott St., Valley Falls, R.I.
Standard Packaging Corp., Johnston Foil Div., 6106 S Broadway, St. Louis 11, Mo.
Standard Plastics Co., 62 Water St., Attleboro, Mass.
Standard Pressed Steel Co., Box 888, Jenkintown, Pa.
Standard Products Co., 316 Fisher Bldg., Detroit, Mich.
Standard Screw Co., Wilson, Conn.
Chicago Screw Co., 2701 Washington Blvd., Bellwood, Ill.
Hartford Machine Screw Co., P.O. Box 1440, Hartford 2, Conn.
Western Automatic Machine Screw Co., 377 Woodland Ave., Elyria, Ohio
Standard Screw Products Co., 506 S Palm Ave., Alhambra, Calif.
Standard Stamping & Perforating Co., 3129 W 49th Place, Chicago 32, Ill.
Standard Steel Sections, Inc., 608 E 133rd St., New York, N.Y.
Standard Tube Co., 24400 Plymouth Rd., Detroit 39, Mich.
Standard Washer & Mat, Inc., 155 Adams St., Manchester, Conn.
Stanley Chemical Co., Berlin St., East Berlin, Conn.
Stanley Works, Stanley Industrial Sales Div., 195 Lake St., New Britain, Conn.
Stanwood Corp., 4819 Cortland, Chicago 39, Ill.
Star Expansion Industries Corp., Pleasant Hill Rd., Mountainville, N.J.
Star Heel Plate Co., Inc., 12 Thornton St., Newark 5, N.J.
Star Porcelain Co., Muirhead Ave., Trenton, N.J.
Star Stainless Screw Co., 194 Union Ave., Totowa, N.J.
Star Stamping Co., 1303 M-139, Benton Harbor, Mich.
Star Wire Screen & Iron Works Inc., 2515 San Fernando Rd., Los Angeles 65, Calif.
Star Woolen Co., Cohoes, N.Y.
State Foundry & Machine Co., Cedar Grove, Wis.
Stauffer Chemical Co. (Ad p 163)
380 Madison Ave., New York 17, N.Y.
Stauffer-Temescal Co., 1201 S 47th St., Richmond, Calif.
Staver Co., Inc., 49 N Saxon Ave., Bay Shore, N.Y.
Stearns-Roger Mfg. Co., P.O. Box 5370, Denver 17, Colo.
Steel Fabricators Co., 1252-B Spruce St., Cleveland 13, Ohio
Steel Heddle Mfg. Co., 2100 Wallegheny Ave., Philadelphia 32, Pa.
Steel Improvement and Forge Co., 970 E 64th St., Cleveland, Ohio
Steel Industries, Inc., 907 Louise Ave., Crawfordsville, Ind.
Steel Protection & Chemical Co., Mooresville, Ind.
Steel Shot Producers, Inc., 4389 Harrison St., Pittsburgh 1, Pa.
Steel, R. & Sons, Inc., 42-21 9th St., Long Island City 1, N.Y.
Steelcote Mfg. Co., 3418 Gratiot St., St. Louis 3, Mo.
Steere Enterprises, Inc. (Ad p 363)
422 S Broadway, Akron 8, Ohio
Steinen, William Mfg. Co., 43 Bruen St., Newark 5, N.J.
Stella Products Corp., 66 Okner Pky., Livingston, N.J.
Stenman, Bror F., West St., Auburn, Mass.
Sterling Alderfer Co., 3850 Granger Rd., Akron 13, Ohio
Sterling Aluminum Products, Inc., 2600 N 3rd St., St. Charles, Mo.
Sterling Bolt Co., 363 W Erie St., Chicago 6, Ill.
Sterling Brass Foundry, Inc., 1640 Sterling Ave., Elkhart, Ind.
Sterling Die Casting Co., 743 39th St., Brooklyn 32, N.Y.
Sterling Foundry Co., 8 Wallace St., Sterling, Ill.
Sterling Models, Belfield & Wister Sts., Philadelphia 44, Pa.
Sterling Molders, Inc., 277 Military Rd., Buffalo 7, N.Y.
Sterrit-Thomas Foundry Co., 32nd & Smallman St., Pittsburgh 1, Pa.
Stevens, Frederic B., Inc., 1800 18th St., Detroit, Mich.
Stevens, J.P. & Co., Inc., 1460 Broadway, New York 36, N.Y.
Steward, D.M. Mfg. Co., E 36th St., Chattanooga, Tenn.
Stewart-Warner Corp., Stewart Die Casting Div., 4535 W Fullerton Ave., Chicago 39, Ill.
Stillman Rubber Co., 5811 Marilyn Ave., Culver City, Calif.
Stillman White Foundry Co., Inc., 42 Dodge St., Providence, R.I.
Stimpson, Edwin B. Co., Inc., 70 Franklin Ave., Brooklyn 5, N.Y.
Stirrup Metal Products Corp., 215 Emmet St., Newark 5, N.J.
Stockwell Rubber Co., Inc., 1117 Shackamaxon St., Philadelphia 25, Pa.
Stokes, F.J. Corp., 5500 Tabor Rd., Philadelphia 20, Pa.
Stone Straw Corp., Stone Paper Tube Div., 900 Franklin St., NE, Washington 17, D.C.
Stoody Co., Whittier, Calif.
Stover Steel Tank & Mfg. Co., 100 S Hancock Ave., Freeport, Ill.
Stowe-Woodward, Inc., 181 Oak St., Newton 64, Mass.
Stranahan Foil Co., Inc., 100 Wesley St., South Hackensack, N.J.
Strick Plastics Co., Perkasie, Pa.
Strong Steel Foundry Co., 33 Norris St., Buffalo 7, N.Y.
Structural Fibers, Inc., 5th Ave., Chardon, Ohio
Struthers Wells Corp., 30 Rockefeller Plaza, New York 20, N.Y.
Stuart Foundry Co., 138 S Junction St., Detroit 9, Mich.
Studebaker - Packard Corp., Gering Plastics Div., N 7th St. & Monroe Ave., Kenilworth, N.J.
Stulz-Sickles Co., 929-939 Julia St., Elizabeth, N.J.
Subax, Inc., Fairmount Plant, Hackensack, N.J.
Sun Chemical Corp., 10th St. & 44th Ave., Long Island City 1, N.Y.
Electro Chemical Corp., 113 E Centre St., Nutley 10, N.J.
Horn, A.C. Co., Inc., 750 3rd Ave., New York 17, N.Y.
Sun Rubber Co., 366 Fairview Ave., Barberton, Ohio
Sun Steel Co., Special Products Div., 1700 W 74th Pl., Chicago 36, Ill.
Sun Tube Corp., 181 Long Ave., Hillside, N.J.
Sunlite Plastics, Inc., 1506 W Pierce St., Milwaukee, Wis.
Superb Light Alloys, Inc., Allen Blvd., Farmingdale, N.Y.
Superior Carbon Products, Inc., 9115 George Ave., Cleveland 5, Ohio
Superior Die Casting Co., 1001 London Rd., Cleveland 10, Ohio
Superior Drawn Steel Co., Beaver Ave., Monaca, Pa.
Superior Foundry, Inc., 3542 E 71st St., Cleveland 5, Ohio
Superior Industries, Inc., 3786 Oakwood Ave., Youngstown 9, Ohio
Superior Mfg. Co., 13th & Rockland Sts., Philadelphia 41, Pa.
Superior Plastics, Inc., 426 N Oakley Blvd., Chicago 12, Ill.
Superior Plating, Inc., 1064 10th Ave. SE, Minneapolis, Minn.
Superior Spinning & Stamping Co., 4057-63 Fitch Rd., Toledo 13, Ohio
Superior Steel Corp., Carnegie, Pa.
Superior Steel & Malleable Castings Co., Benton Harbor, Mich.
Superior Tube Co. (Ad pp 414-415)
Box 191, Norristown, Pa.
Superior-Pacific Galvanizing Co., 1711 E 61st St., Los Angeles 1, Calif.
Supreme Industrial Products Co., 367 N Karlov Ave., Chicago 24, Ill.
Surprenant Mfg. Co., 199 Washington St., Boston 8, Mass.
Swan Rubber Co., 436 E Mansfield St., Bucyrus, Ohio
Swayne-Robinson & Co., 210 Main St., Richmond, Ind.
Swedish Crucible Steel Co., 8801 Conant Ave., Detroit 11, Mich.
Swedlow, Inc. (Ad p 263)
6986 Bandini Blvd., Los Angeles, Calif.
Kevinite Div., 394 N Meridian Rd., Youngstown 9, Ohio
Swepco Tube Corp., 1 Clifton Blvd., Clifton, N.J.
Swett, A.L. Iron Works, 172 Glenwood Ave., Medina, N.Y.
Swift & Co., Adhesive Products Dept., 4115 Packers Ave., Chicago 9, Ill.
Sylvan Plastics Inc., 1617 Pennsylvania Ave., Philadelphia 3, Pa.
Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N.Y.
Chemical & Metallurgical Div. (Ad p 153)
Towanda, Pa.
Parts Div., Warren, Pa.
Sylvester & Co., 17706 Miles Ave., Cleveland 28, Ohio
Symington-Gould Corp., Depew, N.Y.
Synco Resins, Inc., Henry St., Bethel, Conn.
Synthane Corp. (Ad p 234)
River Oaks, Pa.

t

Tallman-McCluskey Fabrics Co., 236 E Monroe, Kirkwood 22, Mo.
Taylor & Co., Inc., 680 Morgan Ave., Brooklyn 22, N.Y.
Taylor & Boggis Foundry, 1290 E 53rd St., Cleveland, Ohio
Taylor Fibre Co. (Ad p 246)
Box 471, Norristown, Pa.
Taylor Forge & Pipe Works, P.O. Box 485, Chicago 90, Ill.
Techalloy Co., Inc., Rte. 113, Rahns 5, Pa.
Technic, Inc. (Ad p 352)
39 Snow St., Providence 3, R.I.
Technical Ply-Woods Sales, 6756 Crandon Ave., Chicago 49, Ill.
Technical Specialties Co., 415 Concord Ave., New York 55, N.Y.
Technical Tape Corp., 240 North Ave., New Rochelle, N.Y.
Teiner, Roland Co., Inc., 134 Tremont St., Everett 49, Mass.
Temco, Inc., 4101 Charlotte Ave., Nashville, Tenn.
Terre Haute Bronze & Brass Foundry, 1114 Sycamore St., Terre Haute, Ind.
Terre Haute Malleable & Mfg. Corp., 2030 N 19th St., Terre Haute, Ind.
Testor Chemical Co., 600 Buckbee, Rockford, Ill.
Texas Aluminum Co., Inc., 512 Mercantile Securities Bldg., Dallas, Tex.
Texas Foundries, Inc., P.O. Box 180, Lufkin, Tex.
Texas Glass Fiber Corp., 147 Island Grove Rd., Grandview, Tex.
Texas Instruments, Inc., Metals & Controls Div. (Ad p 465)
34 Forest St., Attleboro, Mass.
Texas Steel Co., 3901 Hemphill St., Fort Worth 9, Tex.
Texas-U.S. Chemical Co., P.O. Box 667, Port Neches, Tex.
Texstar Corp., Texstar Plastics Div., 1400 Henderson, Fort Worth 1, Tex.
Textile Shield Co., Inc., 1 Groton St., Lawrence, Mass.
Textron, Inc., 50 S Main, Providence, R.I.
Burkart, F. Mfg. Co., 4900 N 2nd St., St. Louis 7, Mo.
Campbell, Wyant & Cannon Foundry Co., Henry St., Muskegon, Mich.
Textron Metals Co., 39 James St., Girard, Ohio
Thalco, 765 S Harvard Blvd., Los Angeles, Calif.
Thatcher Glass Mfg. Co., Inc., McKee Div., Bullitt Ave., Jeannette, Pa.
Thermal American Fused Quartz Co., 15-19 Salem St., Dover, N.J.
Thermal Refractories Corp., 4501 Dell Ave., North Bergen, N.J.
Thinsheet Metals Co., 271-TR Railroad Hill St., Waterbury 20, Conn.
Thiokol Chemical Corp., 780 N Clinton Ave., Trenton 7, N.J.
Thombert, Inc., 316 E 7th St., N, Newton, Iowa
Thompson and Co., 1085 Allegheny Ave., Oakmont, Pa.
Thompson, H. I. Fiber Glass Co., 1733 Cordova St., Los Angeles 7, Calif.
Thompson Industries, Inc., Manhasset, N.Y.
Thompson Pipe & Steel Co., 3001 Larimer St., P.O. Box 2852, Denver 1, Colo.
Thompson Products, Inc., 23555 Euclid Ave., Cleveland 17, Ohio
Light Metals Div., 2269 Ashland Rd., Cleveland, Ohio
Kolcast Industries Div., P.O. Box 250, Minerva, Ohio
Valve Div., 1455 E 185th St., Cleveland 10, Ohio
Thompson, K.W. Tool Co., 20 Dexton Ave., New Hyde Park, N.Y.
Thompson Wire Co., 41 Mildred Ave., Boston 26, Mass.
Thompson-Bremer & Co., 228 N La Salle St., Chicago 1, Ill.
Thomson, Judson L. Mfg. Co., Sawyer Rd., Waltham, Mass.
Thys Co., 6900 Folsom Blvd., Sacramento 19, Calif.
Tiarco Corp., Box 766, Clark, N.J.
Tickle, Arthur Engineering Works, Inc., 21 Delevan St., Brooklyn 31, N.Y.
Al-Fin Div., 21 Delevan St., Brooklyn 31, N.Y.
Timber Products Co., P.O. Box 1032, Medford, Ore.
Timken Roller Bearing Co., Steel & Tube Div., 1835 Dueber Ave., SW Canton 6, Ohio
Tingley Rubber Corp., 903 Ross St., Rahway, N.J.
Tinnerman Products, Inc., Dept. 16, P O Box 6688, Cleveland 1, Ohio
Titan Metal Mfg. Co., Bellefonte, Pa.
Titanium Metals Corp. of America, 233 Broadway, New York 7, N.Y.
Titchener, E. H. & Co., 67 Clinton St., Binghamton, N.Y.
Toepfer & Sons, Inc., 6667 N Teutonia Ave., Milwaukee 9, Wis.
Toledo Industrial Rubber Co., 2238 Smead Ave., Toledo 6, Ohio

In contacting suppliers, please mention the Materials Selector Issue

Toledo Stamping & Mfg. Co., 99 Fearing Blvd., Toledo 7, Ohio
Tompkins Products, 1040 W Grand Blvd., Detroit 8, Mich.
Tool & Mfg. Co., Inc., P.O. Box 10344, Pittsburgh 34, Pa.
Topeka Foundry & Iron Works Co., Inc., 300-324 Jackson St., Topeka, Kan.
Torngren, C.W. Co., Inc., 236 Pearl St., Somerville 45, Mass.
Torrington Co., 59 Field St., Torrington, Conn.
Tousey Varnish Co., 520 W 25th St., Chicago 16, Ill.
Tower Grove Foundry, 4438 Hunt Ave., St. Louis 10, Mo.
Townsend Co., Engineered Fasteners Div., P.O. Box 71, Ellwood City, Pa.

Tovad Corp. (Ad p 260)
Plant Blvd., Latrobe, Pa.

Trane Co., 206 Cameron Ave., La Crosse, Wis.
Transition Metals & Chemicals, Inc., U.S. Magnesium Div., Wallkill, N.Y.
Transue & Williams Steel Forging Corp., 562 W Ely St., Alliance, Ohio
Trenton Brass Co., 621 Prospect St., Trenton, N.J.
Trenton Pipe Nipple Co., 626 Brunswick Ave., Trenton 8, N.J.
Triangle Conduit & Cable Co., Inc., P.O. Box 711, New Brunswick, N.J.
Triangle Stamping Co., 5101 Carnegie Ave., Cleveland 3, Ohio
Trigon Specialties Corp., 1005 S Lafayette Blvd., South Bend 18, Ind.
Trim Alloys, Inc., 30-40 W 3rd St., Boston 27, Mass.
Tri-Point Mfg. & Developing Co., 171 I. U. Willets Rd., Albertson, L.I., N.Y.
Tri-State Plastic Molding Co., 505 4th St., Henderson, Ky.
Trolan Steel Co., P.O. Box 2426, Charleston 29, W. Va.
Trostel, Albert Packings, Ltd., Lake Geneva, Wis.

Troy Blanket Mills (Ad p 327)
200 Madison Ave., New York, N.Y.

Truche Leather Co., Peabody, Mass.
True Alloys, Inc., 284 S Summit St., Detroit 9, Mich.
Tube Distributors Co., Inc., 1415 Kellum Pl., Garden City, N.Y.
Tube Methods, Inc., Depot & Rambo Sts., Bridgeport, Pa.
Tube Reducing Corp., 520 Main Ave., Wallington, N.J.
Tube Turns Plastics, Inc., 2929 Magazine St., Louisville 11, Ky.
Tubular Rivet & Stud Co., Weston Ave., Quincy 70, Mass.
Tuff Clad, Inc., W Oak St. Extension, Kent, Ohio
Turco Products, Inc., 6135 S. Central Ave., Los Angeles 1, Calif.
Turner Halsey Co., 40 Worth St., New York 13, N.Y.
Turner & Seymour Mfg. Co., Lawton St., Torrington, Conn.

Twin City Die Castings Co. (Ad p 418)
Talmadge & 33rd Aves., SE, Minneapolis 14, Minn.

Twitchell, E. W., Inc., 2806 N 3rd St., Philadelphia 33, Pa.
Tyer Rubber Co., Andover, Mass.
Tyler, W.S. Co., 3615 Superior Ave., Cleveland 14, Ohio

U

UBS Chemical Corp., 491 Main St., Cambridge 43, Mass.
Uddeholm Co. of America, Inc., 155 E 44th St., New York 17, N.Y.
Udylite Corp., 1651 Grand Blvd., Detroit 11, Mich.
Ulbrich Stainless Steels Corp., Old Colony Rd., Wallingford, Conn.
Ullmann, Inc., 4305 N 127th St., Butler, Wis.
Uniform Tubes, Inc., Level & School Rds., Collegeville 2, Pa.
Union Asbestos & Rubber Co., 1111 W Perry St., Bloomington, Ill.
Union Carbide Corp., 270 Park Ave., New York 17, N.Y.
Haynes Stellite Co. Div., 1020 W Park Ave., Kokomo, Ind.
Linde Co. Div., 270 Park Ave., New York 17, N.Y.

National Carbon Co. (Ad p 307)
270 Park Ave., New York 17, N.Y.

Silicones Div. (Ad p 277)
270 Park Ave., New York 17, N.Y.

Union Carbide Chemicals Co., Textile Fibers Dept., 270 Park Ave., New York 17, N.Y.

Union Carbide Metals Co. (Ad p 181)
270 Park Ave., New York 17, N.Y.

Union Carbide Plastics Co. Div. (Ad p 257)
270 Park Ave., New York 17, N.Y.

Visking Co. Div., 6733 W 65th St., Chicago 38, Ill.
Union Chemical Corp., 410 Frelinghuysen Ave., Newark 5, N.J.
Union Forging Co., 500 North St., Endicott, N.Y.
Union Iron Works, P.O. Box 2135, Spokane, Wash.
Union Paste Co., 1605 Hyde Park Ave., Hyde Park 36, Mass.
Union Screw & Mfg. Co., Box 25, Imperial, Pa.
Union Spring & Mfg. Co., 2nd Ave. & 8th St., New Kensington, Pa.
Union Steel Corp., Stanley Terrace, Union, N.J.
Union Tank Car Co., 228 N LaSalle, Chicago, Ill.
Graver Tank & Mfg. Co. Div., 4809 Tod Ave., East Chicago, Ind.
Unique Wire Weaving Co., Inc., 276 Ramset Ave., Hillside, N.J.

Unicast Corp. (Ad p 467)
Water Works Dr., Toledo 9, Ohio

United Carbon Products Co., 1310 N Madison St., Bay City, Mich.
United Cork Cos., 15 Central Ave., Kearney, N.J.
United Forge Co., 277 Dubois, Detroit 7, Mich.
United International Research, Inc., 38-15 30th St., Long Island City 1, N.Y.
United Metal Products Corp., 8101 Lyndon Ave., Detroit 38, Mich.
United Mineral & Chemical Corp., 16 Hudson St., New York 13, N.Y.
United Refining & Smelting Co., 2920 W Carroll Ave., Chicago 12, Ill.
United Rubber & Chemical Co., P.O. Box 149, Baytown, Tex.
United Screw & Bolt Corp., 2513 W Cullerton Ave., Chicago 8, Ill.
United Shoe Machinery Corp., 140 Federal St., Boston 7, Mass.
United Sintered Alloys, St. James, L.I., N.Y.
United Smelting & Aluminum Co., Inc., P.O. Box 1910, New Haven 9, Conn.
U.S. Bronze Powder Works, Inc., Flemington, N.J.
U.S. Ceramic Tile Co., Sparta Mfg. Co., Dover, Ohio
U.S. Challenge & Challenge Co., 1441 N Kingsburg St., Chicago 22, Ill.
U.S. Extrusions Corp., 120 Old Broadway, Garden City Park, N.Y.
U.S. Flexible Tubing Co., Bartlett, Ill.
U.S. Gasket & Shim Co., 2743 2nd St., Cuyahoga Falls, Ohio
U.S. Gypsum Co., 300 W Adams St., Chicago 6, Ill.

U.S. Magnet & Alloy Corp. (Ad p 420)
266 Glenwood Ave., Bloomfield, N.J.

U.S. Metal Products Co., P.O. Box 1067, Erie, Pa.
U.S. Mica Co., Inc., 1525 Circle Ave., Forest Park, Ill.
U.S. Pipe and Foundry Co., 3300 1st Ave. N, Birmingham 3, Ala.
U.S. Plywood Corp., 55 W 44th St., New York 36, N.Y.
U.S. Polymeric Chemicals, Inc., Box 546, Stamford, Conn.
U. S. Reduction Co., Chicago Ave. & Melville St., East Chicago, Ind.
U. S. Rubber Co., 1230 Ave. of the Americas, New York 20, N.Y.
Footwear Div., 2638 Pulaski Rd., Chicago 39, Ill.

Kem-Blo Dept. (Ad p 250)
Naugatuck, Conn.

Mechanical Goods Div., 4300 New Haven Ave., Fort Wayne, Ind.

Naugatuck Chemical Div. (Ad p 247)
Elm St., Naugatuck, Conn.

Textile Div., 1230 Ave. of the Americas, New York 20, N.Y.
U. S. Smelting, Refining & Mining Co., 62 William St., New York, N.Y.
U.S. Steel Corp., 525 William Penn Pl., Pittsburgh 30, Pa.

American Steel & Wire Div. (Ad pp 90-91)
Rockefeller Bldg., Cleveland 13, Ohio

Columbia-Geneva Steel Div., 120 Montgomery St., San Francisco 6, Calif.
National Tube Div., 525 William Penn Pl., Pittsburgh 30, Pa.
Tennessee Coal and Iron Div., P.O. Box 599, Fairfield, Ala.
United States Steel Supply Div., 208 S La Salle St., Chicago 4.
U. S. Stoneware Co., P.O. Box 350, Akron 9, Ohio
Alite Div., P.O. Box 119, Orrville, Ohio

Colonial Rubber Co. Div. (Ad p 441)
706 Oakwood St., Ravenna, Ohio

Conneaut Rubber & Plastics Co. Div. (Ad p 447)
P.O. Box 621, Conneaut, Ohio

U.S. Valve & Mfg. Co., 256 E Grand Ave., South San Francisco, Calif.
United Wire & Supply Corp., 1497 Elmwood Ave., Providence 7, R.I.
United-Carr Fastener Corp., 31 Ames St., Cambridge 42, Mass.
New England Tape Co. Div., 30 Tower St., Hudson, Mass.
Unity Machine & Tool Corp., 2727 E Westmoreland St., Philadelphia 34, Pa.
Universal Castings Corp., 5821 W 66th St., Chicago 38, Ill.
Universal Converting Corp., 1125 County St., New Bedford, Mass.
Universal Unlimited, Inc., Pratt Oval, Glen Cove, N.Y.
Universal-Cyclops Steel Corp., Bridgeville, Pa.
Empire-Reeves Steel Div., Bridgeville, Pa.
University of Tennessee, Dept of Chemistry, University Sta., Knoxville 16, Tenn.
Uniworld Research Corp. of America, 9802 Euclid Ave., Cleveland 6, Ohio
Upson Co., Stevens St., Lockport, N.Y.
Urrite Plastics Fabricators, 4740-2 S Durfee Rd., Pico-Rivera, Calif.
Utica Drop Forge & Tool Co., 2409-15 Whitesboro St., Utica 4, N.Y.
Utica General Jobbing Foundry, Inc., 1801 Foundry St., Utica 3, N.Y.
Utica Radiator Corp., Dwyer Ave., Utica, N.Y.
Utility Mfg. Co., 2443 Boston Rd., North Wilbraham, Mass.
Utility Steel Foundry, 3320 E Slauson, Vernon, Calif.

V

Valley Iron Works, 81 E Water St., St. Paul 7, Minn.
Valley Steel Casting Co., Foot of 11th St., Bay City, Mich.
Valley-National Corp., Clark St., Millidale, Conn.

Vanadium Corp. of America (Ad p 86)
420 Lexington Ave., New York 17, N.Y.

Vanadium-Alloys Steel Co., Latrobe, Pa.
Anchor Drawn Steel Co., Latrobe, Pa.
Colonial Steel Div., Monaca, Pa.
Metal Forming Corp. Div., 1937 Sterling Ave., Elkart, Ind.
Vanamatic Co., 204 S Jefferson St., Delphos, Ohio
Van der Horst Corp., Olean, N.Y.
Van Dorn Iron Works Co., Colonial Plastics Div., 2685 E 79th St., Cleveland 4, Ohio
Van Huffell Tube Corp., Larchmont Ave., NE, Warren, Ohio
Van Pelt Corp., Service Steel Div., Box 532, Detroit 32, Mich.
Van Valkenburg, L.D. Co., Box 190, Holyoke, Mass.
Varcum Chemical Corp., P.O. Box 476, Niagara Falls, N.Y.
Varflex Corp., 512 W Court St., Rome, N.Y.
Variety Stamping Corp., 12695 Elmwood Ave., Cleveland 11, Ohio
Vascoloy-Ramet Corp., 800 Market St., Waukegan, Ill.
Veeder-Root Inc., 70 Sargeant St., Hartford 2, Conn.
Vellumoid Co., 54 Rockdale St., Worcester 6, Mass.
Velcro Sales Corp., 681 5th Ave., New York 22, N.Y.
Veremere, E.A. Inc., 11623 S Broadway, Los Angeles 61, Calif
Victor Equipment Co., 844 Folsom St., San Francisco 7, Calif.
Victor Mfg. & Gasket Co., 5750 W Roosevelt Rd., Chicago 50, Ill.
Victor Steel Products Corp., 1175 Leggett Ave., New York 59, N.Y.
Victory Plastics Co., 81 Apsley St., Hudson, Mass.
Viking Copper Tube Co., 16700 St. Clair Ave., Cleveland, Ohio
Viking Pump Co., George & Wyth Sts., Cedar Falls 1, Iowa
Viplax Products Corp., 408 E Warren St., Beverly, N.J.
Vogt Mfg. Corp., 100 Fernwood Ave., Rochester, N.Y.
Volco Brass & Copper Co., Kenilworth, N.J.
Volkert Stampings, Inc., 222-34 96th Ave., Queens Village 29, N.Y.
Vollrath Co., Contract Div., 1236 N 18th St., Sheboygan, Wis.
Vulcan Foundry Co., Oakland, Calif.
Vulcan Iron Works, 730 S Main St., Wilkes Barre, Pa.
Vulcan Mfg. Co., Box 22, Cincinnati 22, Ohio
Vulcan Metal Products, Inc., 2801 6th Ave., S, Birmingham, Ala.
Vulcan Rail & Construction Co., 59-30 54th St., Maspeth, N.Y.
Vulcanized Rubber & Plastics Co., 5 S Pennsylvania Ave., Morrisville, Pa.

W

W. F. Mfg. Co., 1509 Gardena Ave., Glendale 4, Calif.
WLS Stamping Co., 3292 E 80th St., Cleveland 4, Ohio

Wabash Metal Products Co., Inc., P.O. Box 305, Wabash, Ind.
Wagner Malleable Iron Co., 1275 E Sangamon, Decatur, Ill.
Wagner, E.R. Mfg. Co., 4611 N 32nd St., Milwaukee 9, Wis.
Wagner Plastic Corp., Rte. 88, Lakewood, N.J.
Wagner Specialty Co., 647 Dodge St., Burlington, Wis.
Wah Chang Corp. (Ad p 164)
233 Broadway, New York 7, N.Y.
Waimet Alloys Co. (Ad p 82)
1999 Guoin St., Detroit 7, Mich.
Wakefield Bearing Corp., 45 Foundry St., Wakefield, Mass.
Waldes Kohinoor, Inc., 47-16 Austel Pl., Long Island City 1, N.Y.
Waldman, Jos. & Sons, Epoxy Products Div. (Ad p 499)
137 Coit St., Irvington, N.J.
Walker Forge, Inc., 2000 17th St., Racine, Wis.
Wall Colmonoy Corp., Stainless Process Div. (Ad p 498)
19345 John R. St., Detroit 3, Mich.
Wall, P. Mfg. Co., Erie St., Grove City, Pa.
Wall Tube & Metal Products Co., P.O. Box 330, Newport, Tenn.
Wallace Supplies Mfg. Co., Wallace Tube Co. Div., 1300 Diversey Pkwy., Chicago 14, Ill.
Wallingford Steel Co., 80 Valley St., Wallingford, Conn.
Wal-Mar Corp., 2800 Bernice Rd., Lansing, Ill.
Walrod Machine Products, 5225 SE 7th Ave., Portland 2, Ore.
Waltham Foundry Co., 71 Felton St., Waltham 54, Mass.
Ward, H.H. Co., 4th & Engle Sts., Chester, Pa.
Warner Mfg. Corp., 265 Watsessing Ave., Bloomfield, N.J.
Warren Belting Co., 33 Arctic St., Worcester 8, Mass.
Warren Bros. Roads Co., 32 Potter St., Cambridge 42, Mass.
Wasco Products, Inc., 5 Bay State Rd., Cambridge 38, Mass.
Washburn Wire Co., Phillipsdale Div., Bourne Ave., Phillipsdale, R.I.
Washington Iron Works, 1500 6th Ave., S, Seattle 4, Wash.
Washington Mfg. Co., Inc., P.O. Box 370, Washington, Iowa
Washington Steel Corp., Washington, Pa.
Waterbury Buckle Co., 952 S Main St., Waterbury 20, Conn.
Waterbury Cos., Inc., P.O. Box 1032, Waterbury, Conn.
Waterbury Pressed Metal Co., 300 Chase Ave., Waterbury 14, Conn.
Waterbury Rolling Mills, Inc., Box 550, Waterbury 20, Conn.
Waterman Industries, Inc., 515 S. G St., Exeter, Calif.
Watertown Mfg. Co., Echo Lake Rd., Watertown, Conn.
Watson-Standard Co., 225 Galveston Ave., Pittsburgh 12, Pa.
Waukesha Foundry Co. (Ad p 451)
Lincoln Ave., Waukesha, Wis.
Wayne Agricultural Works, Inc., Goldsboro, N.C.
Wayne Chemical Products Co., 9470 Copland Ave., Detroit 17, Mich.
Wayne Foundry & Stamping Co., 3100 Hubbard St., Detroit 10, Mich.
Weatherhead Co., 128 W Washington Blvd., Fort Wayne 1, Ind.
Weber-Knapp Co., 441 Chandler St., Jamestown, N.Y.
Webster Mfg., Inc., 1100 W Davis St., Tiffin, Ohio
Weckesser Co., 5713 Northwest Hwy., Chicago 46, Ill.
Wedler Bros., Inc., 1535 E 38th St., Cleveland 14, Ohio
Weiskittel, Harry C. Co., Inc., 4901 Pulaski Hwy., Baltimore 24, Md.
Welding Apparatus Co., 2750 W Van Buren St., Chicago 12, Ill.
Wellington Sears Co., 111 W 40th St., New York 18, N.Y.
Wellman, S.K. Co., 20 Egbert Rd., Bedford, Ohio
Wellman Bronze and Aluminum Co., 9401 Woodland Ave., Cleveland 4, Ohio
Wells, A.H. & Co., Inc., 100 E Aurora St., Waterbury, Conn.
Wells Aluminum Corp., 50 Henry St., North Liberty, Ind.
Wellsville Fire Brick Co., Wellsville, Mo.
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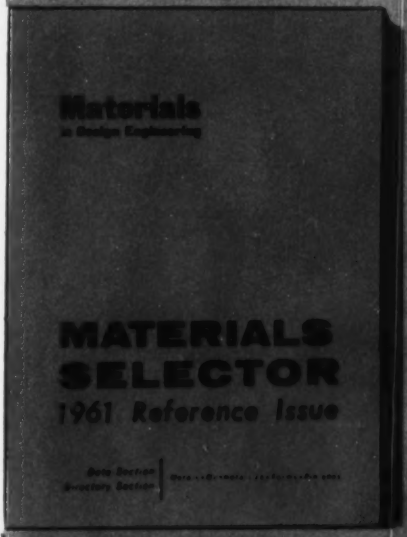

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for example –

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Alloy steels
Stainless steels
Tool steels
Heat resistant alloys
Gray, malleable, nodular irons

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2 NONFERROUS METALS

for example –

Aluminum
Copper, brass, bronze
Magnesium
Zinc, lead, tin
Nickel
Titanium
Zirconium
Low melting alloys
Noble metals
Rare metals
Cemented carbides

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3 NONMETALLIC MATERIALS

for example –

Plastics
Rubbers
Silicones
Vulcanized fibres
Impregnated materials
Wood-base materials
Ceramics
Refractories
Glasses and fiberglass
Carbon and graphite
Industrial felts, fabrics and fibers
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